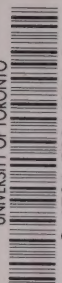


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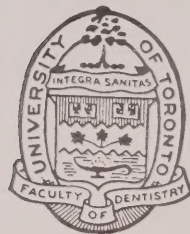
Dental fluorosis survey relative to
brick plant fluoride emissions in
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DENTAL FLUOROSIS
SURVEY RELATIVE TO BRICK
PLANT FLUORIDE EMISSIONS
IN TORONTO AND BRAMPTON, ONTARIO

BY

D.W. LEWIS, C. ONDRACK,
J.T. MAYHALL AND A.M. HUNT

JANUARY 1982

RESEARCH REPORT

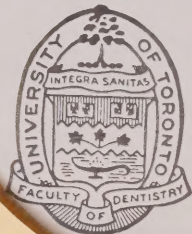
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D.W. LEWIS, C. ONDRACK,
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JANUARY 1982

Research Report No. 46

Research supported in full through
Ontario Ministry of Health
Grant (RD 101A)

Dental Health Care Services Research Unit
Department of Community Dentistry
Faculty of Dentistry, University of Toronto
124 Edward Street
Toronto, Ontario, Canada
M5G 1G6

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SUMMARY

Teeth are very sensitive to systemic fluoride as they develop. Beyond certain threshold levels of systemic fluoride tooth calcification may be disturbed so that such teeth subsequently display characteristic markings after eruption. Teeth are considered good indicators of previous systemic fluoride intake since these markings become increasingly more severe as the amount of fluoride increases beyond amounts considered optimal for decay reduction, beyond the recommended 1.0-1.2 ppm fluoride in water fluoridation for example. Teeth in both fluoridated and non-fluoridated areas are also known to display non-specific opacities of non-fluoride origin. The prevalence of these latter defects varies but 20% is a commonly quoted figure, although higher figures are sometimes used.

According to the lime-candle monitoring devices used by the Ontario Ministry of the Environment, the brick plants in Toronto and Brampton have been shown to have gaseous emissions of fluoride in excess of the Ministry's recommended maximum levels. Because teeth are so sensitive to fluoride during their development, the present survey was undertaken to determine whether these emissions imposed any dentally identifiable extra burden of fluoride in children living near the brick plants when their teeth developed. Residency location in the region of the brick plants at this time was important since previous lime-candle fluoride readings (and those collected more recently) indicated a great decrease in gaseous fluoride as distance from the plants increased and higher fluoride levels according to the dominant wind direction.

In the dental survey 1442 children (985 in East York/Toronto and 457 in Brampton) in senior kindergarten, grades 2 and 6 were examined for dental fluorosis (using the new Thylstrup and Fejerskov index) and non-specific opacities on one anterior and one posterior tooth. Subsequently, comparisons were made of the dental fluorosis and opacity scores among the 590 East York/Toronto children (60% of the original number since the others had lived elsewhere during the critical tooth formation period) and 99 Brampton children (22% of the original number)



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according to the direction (NE, SE, SW, NW quarter circle) and distance (0-0.75, 0.75-1.0, 1.0-2.75 miles) of their residency from the brick plants during formation of their "target" teeth. As well, these scores overall and for various sub-groups according to distance and direction were compared with those of Ontario control group children who had utilized fluoridated water at the time the examined teeth were developing but had not been exposed to air-borne fluoride beyond background levels. These controls amounted to 119-148 children now residing near the Toronto brick plant and 174-210 children now residing near the Brampton brick plant. Since certain foods (e.g., tea and fish) and dental products (e.g., dentifrices, mouthrinses, and fluoride tablets) if ingested in high enough quantities could affect the extent of dental fluorosis, a qualitative assessment of their usage was made to see whether they might be causally associated with dental fluorosis independently of, or in combination with air-borne fluoride.

The comparisons of the distributions of the fluorosis scores, the non-specific tooth opacities and the combination of these two for each examined tooth surface developing within a two mile radius of each brick plant showed almost without exception an irregular and non-significant pattern of distribution. Thus, to the extent that differences in exposure to air-borne fluoride can be identified by distance and direction, there was no reason to attribute the fluoride and non-fluoride tooth opacities found to the fluoride emissions from either brick plant. Indeed, although these relationships were non-significant, the distributions of fluorosis and/or opacities often were the opposite to what might be expected if environmental fluoride were causally implicated. For example, those generally "downwind" often had lower scores than those generally "upwind", and those living in or near areas with apparently lower lime-candle readings often had higher scores than those with higher readings.

Comparisons of the fluoride and non-fluoride opacities of children residing near the brick plants when their teeth developed revealed no differences from those of control children who had similar exposure to water fluoridation but no known environmental exposure beyond background levels. These findings provided further evidence of the lack of

an environmental influence due to air-borne fluoride near the Toronto and Brampton brick plants being positively associated with dental fluorosis.

Regarding the explanatory value of dietary and dental products containing fluoride, there were no clear indications that previous dietary or dental fluoride use was positively related to fluorosis score differences or that it interacted with possible differences in environmental fluoride according to residency location to give increased fluorosis.

In summary, this study provides no evidence that earlier possible variations in exposure to air-borne, dietary or preventive dental fluorides have resulted in identifiable differences in dental fluorosis. Whatever additional systemic fluoride, if any, some children may have experienced during the period when the examined teeth were calcifying was apparently below the threshold levels needed to produce identifiable differences in the prevalence and extent of dental fluorosis in these children.

The report ends with a description and discussion of the dental fluorosis and non-specific opacities found in the teeth of all the children examined.

ACKNOWLEDGEMENTS

This research was supported by Ontario Ministry of Health research grant RD101A between September 1, 1980 and March 31, 1981. Later, some funds from Ontario Ministry of Health grant DM518 were utilized to expedite the completion of the analysis and this report.

A number of individuals in the Ontario Ministry of Labour and the Ministry of Environment were very helpful at various stages of this project. These include Dr. M. Fitch, Director of the Special Studies and Services Branch of the Ministry of Labour and especially his associate Dr. T. McGrath. Mr. B. Martin, Mr. G. Nagy and Mr. K. Heidorn of the Ministry of Environment were also very helpful.

The public and separate school boards of education and their research committees in East York, the City of Toronto and Brampton were very co-operative (City of Toronto Board of Education, East York Board of Education, the Metropolitan Separate School Board, the Dufferin-Peel Roman Catholic Separate School Board and the Peel Board of Education). The principals and staff in the schools in which the survey was conducted were also very helpful.

In the early planning phase of the research the Medical Officers of Health and the Dental Directors of the City of Toronto, East York and Peel were supportive and provided the initial maps and statistical information on school enrolment.

We are especially indebted to the project's field staff who so ably carried out the parental contacting, survey form collection and organizational work within the schools and later, the data coding: Kiki Pantazis; Heather Kranias; Mary Keyser; Annabel Reinis; and Gillian Federico. Also at the Faculty of Dentistry, Betty Conroy, Judy McGhie and Maureen White helped a great deal. Henzel Jupiter ably completed the sometimes complex computer programming. Professor Anders Thylstrup kindly spent time with the study's dental examiners during a visit to Toronto. Finally, the dental recording assistants, Mindy Mayhall and Grace Hunt, provided a high level of skill and support to the dental examination component of the study.

We are very grateful to all these individuals and agencies.
Thank you.

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DENTAL FLUOROSIS SURVEY RELATIVE TO BRICK PLANT
FLUORIDE EMISSIONS IN TORONTO AND BRAMPTON, ONTARIO

I. BACKGROUND TO THE STUDY

INDUSTRIAL FLUORIDE EMISSIONS

Monitoring by the Ontario Ministry of the Environment of industrial, gaseous fluoride emissions has revealed high emissions from two brick plants, one located near the Bayview extension in Toronto's Don Valley and the other adjacent to highway 10 in north Brampton, Ontario. In each instance some damage to vegetation and higher than recommended* 30-day accumulations of fluoride, using the lime-candle method, have been recorded in Toronto since 1972 and in Brampton since 1975. The distribution of most of the fluoride seemed largely to be localized to the immediate area of the plants; however, lime-candle readings above the stated acceptable criteria* were found from about one-quarter to one-half of a mile from the plants, sometimes in residential areas.

MEASUREMENT OF HUMAN FLUORIDE EXPOSURE

Current exposure to fluoride is most often measured by the amount of fluoride ion in the urine.** In older individuals an approximate balance between body fluoride intake and output is established. In younger, growing persons some of the fluoride taken in is deposited in bones and teeth as they develop.

Previous exposure to fluoride is best assessed by examination of those teeth that developed during a certain period when the fluoride was available. Teeth are very sensitive to available fluoride when they calcify. Above a certain threshold fluoride level, disturbances in calcification occur which, unlike in bone,

* The stated criteria are $40 \text{ ug F/100 cm}^2/30 \text{ days}$ for April 15 - October 15 and 80 ug for October 16 - April 14.

** An independent study of fluoride in the urine of certain persons residing near these two plants was undertaken in 1981 by the Special Studies and Services Branch of the Ontario Ministry of Labour. Their findings are not reported here.

are permanently and characteristically recorded in those portions of the enamel surfaces of the particular teeth developing at the time of the fluoride exposure above threshold. This relationship between the amount of available fluoride (particularly in the drinking water) during tooth development before tooth eruption and the extent and type of tooth mottling (fluorosis) seen after tooth eruption is well established. Approximate dose-response curves for this relationship have been developed, as have standard criteria for scoring dental fluorosis.

COMPLICATIONS

The ingestion of fluoride in foods and beverages, toothpastes, bottled water, preventive dental preparations and drinking water (Toronto and Brampton have about 1 mg. F/litre) must be considered as well as that inhaled. Normally the amount inhaled and absorbed through the lungs into the body represents a very small part of the total daily fluoride intake from all sources (about 3%).* These other dietary and extra-dietary sources of fluoride complicate somewhat the assessment of air-borne fluoride-induced tooth enamel change (if any) but through appropriate questionnaires, the effects of these sources in "exposed" and "control" children may be accounted for in the analysis. Another complicating factor is that other non-fluoride, permanent enamel opacities occur in the teeth of 15% to 20% of the population even though these defects often are unknown to the individual, only being identifiable on the basis of a careful dental examination. By detailed examination these defects are able to be differentially distinguished from the characteristic, fluoride-induced ones.

* Six percent is the figure mentioned in the Long Harbour, Newfoundland report. This, however, is probably too high a figure since it is based on the possible exposure of workers in a fluoride-emitting industry with only moderate control of emissions (8 ug F per cu. m. of air). (Final Report of the Canadian Public Health Association's Task Force on Fluoride. Canadian Public Health Association, Ottawa, 1978.) Three percent would thus be a more realistic estimate.

A SUMMARY OF TORONTO AND BRAMPTON BRICK PLANT FLUORIDE EMISSIONS

Data provided by the Ministry of the Environment from three types of fluoride monitoring in the area surrounding the two brick plants were examined: (i) vegetation injury assessments; (ii) phytotoxicology (chemical analysis of fluoride concentration in foliage); and (iii) lime-candle readings. The first two types of monitoring began in 1972 (Toronto) and 1973 (Brampton) and have continued to the present, whereas lime-candle data are available between 1972 and 1979* for Toronto and between 1975 and 1979* for Brampton.

Comprehensive, knowledgeable interpretation of these data must be made by the appropriate scientists involved. So for the purpose of this report a brief, interpretive summary of what the data appear to show is all that is provided. Regarding injury to vegetation, it appears that there has been some trace to light injury within, say three hundred meters from the plants and beyond this distance, more noticeably to the south of the plants, some occasional evidence of slight or trace injury to vegetation. Chemical analysis of foliage for fluoride has demonstrated concentrations above the expected, background levels immediately adjacent to the plants but often background readings beyond this distance. There are, however, foliage concentrations of fluoride above background readings at some of the sample locations in residential parts of the surrounding communities, say, 700-1000 meters from the brick plants. Generally, these latter sites are south of the plants, but this is not always so. It is believed that the dispersal of fluoride from these plants is generally consistent with each area's wind direction patterns.

Table 1 gives the mean annual lime-candle fluoride readings for six lime-candle sites at the Toronto brick plant and four sites at Brampton brick plant.* In order to emphasize that these annual means hide much variability in the month-to-month fluoride readings, the annual monthly minimum and maximum readings are listed in Table 2. The stated acceptable (maximum) criteria are $40 \text{ ug F/100 cm}^2/30 \text{ days}$ for six months of each year (the "growing" months Apr. 15 - Oct. 15) and $80 \text{ ug F/100 cm}^2/30 \text{ days}$ for the remaining six months. It can be seen

* Lime-candle readings have actually continued; at the initiation of this study only the 1979 data were available. Also, more lime-candles are now used.

TABLE 1

TORONTO BRICK -- LIME CANDLE FLUORIDE READINGS -- MEANS*

<u>Lime Candle Station No.</u>	<u>Approx. Location**</u>	<u>Yearly Mean (ugF/100 cm²/30 days)***</u>							
		<u>1972</u>	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
		(7 mos.)						(4 mos.)	
1. 32001	immed. S.	715	680	658	673	806	1010	1314	948
2. 31024	~ .33 mi. SSE	122	193	186	268	282	314	359	284
3. 32002	~ .4 mi. E.	73	142	118	114	132	193	239	276
4. 31023	~ .25 mi. WSW	55	124	72	83	40	100	110	129
5. 31022	~ .33 mi. NNW	26	39	30	32	24	44	48	43
6. 32003	~ .4 mi. N	32	36	30	27	20	32	50	31

BRAMPTON BRICK -- LIME CANDLE FLUORIDE READINGS -- MEANS*

<u>Lime Candle Station No.</u>	<u>Approx. Location**</u>	<u>Yearly Mean (ugF/100 cm²/30 days)***</u>				
		<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>
		(4 mos.)			(4 mos.)	
1. 46080/84	immed. S	465	520	1572	1470	1219
2. 46081	~ .5 mi. SSW	120	114	163	203	181
3. 46082	~ .4 mi. SE	102	131	136	143	180
4. 46083	~ .85 mi. SE	81	38	117	81	69

* The stated criteria are 40 for Apr. 15 - Oct. 15 and 80 for Oct. 16 - Apr. 14.

** Relative to the brick plant.

*** Often there is great individual month-to-month variation which the annual mean conceals. This is demonstrated on Table 2.

TABLE 2

TORONTO BRICK -- LIME CANDLE FLUORIDE READINGS - MINIMA AND MAXIMA

Lime Candle Station No.	Approx. Location**	Yearly Minima and Maxima (ug F/100 cm ² /30 days)					
		<u>1972</u> (7 mos.)	<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u> <u>1978</u> <u>1979</u> (4 mos.)
1. 32001	immed. S	13-2150	200-1250	260-1056	280-1940	581-1190	488-1629 799-2325 447-1432
2. 31024	~.33 mi.SSE	19-210	100-330	83-458	98-907	145-419	100-617 164-648 75-583
3. 32002	~.4 mi.E	11-150	55-320	42-195	59-189	59-285	112-387 118-652 160-441
4. 31023	~.25 mi.WSW	3-170	32-310	12-187	20-187	14-117	15-300 28-447 93-169
5. 31022	~.33 mi.NNW	4-32	8-60	9-88	12-64	6-90	17-71 21-72 36-59
6. 32003	~.4 mi.N	6-85	24-50	12-65	3-52	6-35	11-49 24-75 25-39

BRAMPTON BRICK -- LIME CANDLE FLUORIDE READINGS - MINIMA AND MAXIMA

Lime Candle Station No.	Approx. Location**	Yearly Minima and Maxima (ug F/100 cm ² /30 days)			
		<u>1975</u> (4 mos.)	<u>1976</u>	<u>1977</u>	<u>1978</u> <u>1979</u> (4 mos.)
1. 46080/84	immed. S	255-614	21-1728	370-3111	227-2777 433-2342
2. 46081	~.5 mi.SSW	95-140	12-395	16-510	70-473 86-352
3. 46082	~.4 mi.SE	78-142	32-251	33-347	46-290 111-258
4. 46083	~.85 mi.SE	43-125	5-91	44-375	51-120 37-84

** Relative to the brick plant.

in Tables 1 and 2 that four (and perhaps five) of the six lime-candle location fluoride readings in Toronto and all four of the Brampton fluoride readings exceed these stated criteria. Again, there are exceptions in certain years at certain locations (and in some months).

The location of the lime-candles is mentioned on Table 1 and portrayed in Figures 1 and 2. It is clear that the very high readings are in the immediate areas of the plants. It is equally clear that some of the readings which exceed the stated criteria, are in residential areas, generally to the south of the plants (actually, no lime-candle stations are situated to the north of the Brampton plant).

It must be stressed that there is, at present, no completely satisfactory method of determining the amount of fluoride in a given volume of air from the lime-candle readings.* Therefore, the quantity of fluoride potentially absorbed by the lungs into the body below or above the criterion levels is not known. Consequently, it cannot be inferred that lime-candle fluoride readings above the stated criteria to the levels seen in Tables 1 and 2, are damaging to human health; neither can the inference be drawn that such levels do not cause damage to humans. It has however, been recognized by work in Florida that lime-candle readings of 100 to 200 indicate potential difficulties for cattle and citrus vegetation.**

To put the Toronto-Brampton situation in perspective, the following passage from the Final Report of the Canadian Public Health Association's Task Force on Fluoride, Long Harbour, Newfoundland (1978 - p. 29,30) suggests that even with high air concentrations of fluoride, the amount absorbed from the lungs represents only a very small fraction (about 6%) of the amount of fluoride ingested daily by the average person:

* The Ontario Ministry of the Environment is currently researching this problem by comparing volumetric air and lime-candle fluoride readings at the same sites. A few similar studies have been done in other countries.

** Source: Report of the Committee Appointed to Inquire into and Report Upon the Pollution of Air, Soil and Water in the Townships of Dunn, Moulton, and Sherbrooke, Haldimand County. September, 1968. Queen's Printer, Toronto. p. 61.

If a person is exposed to ambient air containing about eight micrograms (ug) of fluoride per cubic meter, the maximum average concentration projected in the vicinity of a fluoride-emitting industry with only moderate control equipment, his total daily intake from this source is calculated to be about 160 ug. This is still very low when compared with the daily dietary fluoride intake estimated for Newfoundland as being 2,740 ug ingested by the average person in food and water (including 1,000 ug from tea).

The lime-candle readings recorded for the Toronto and Brampton brick plants indicate much lower and less widely spread fluoride accumulations than experienced near Port Maitland, Ontario. At the ERCO plant there in 1965, for example, fluoride readings of 100 were recorded as far as 6 miles from the plant, and readings of 200 as far as 4 miles away.*

Despite these higher lime-candle fluoride readings at Port Maitland, the dental findings there were essentially negative (R.C. Burgess and D.W. Lewis 1968*, and an unpublished follow-up survey in 1971). Similarly, the Long Harbour, Newfoundland, dental findings displayed no positive association between environmental fluoride exposure and dental fluorosis (H.J. Hann, and J.J. Philion, 1978).** Nevertheless, local concern, highlighted by newspaper articles emphasizing the higher than recommended fluoride emissions from the Toronto and Brampton brick plants and the proximity of these plants to residential areas, led to planning for a study.

THE DECISION TO STUDY

Meetings of the Medical Officers of Health for the City of Toronto, Borough of East York and Regional Municipality of Peel and officials from appropriate Ministries of the Ontario government in mid-1979 led to the suggestion of the need for a fluorosis dental survey. The principal author of this Report was asked to prepare the research protocol for such a study. The protocol was submitted in February 1980.

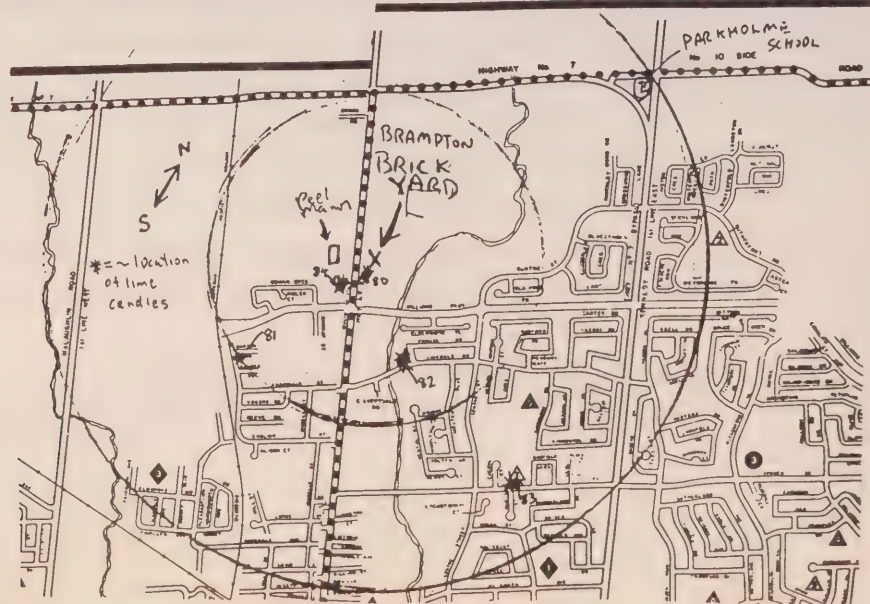
* Source: Report of the Committee Appointed to Inquire into and Report Upon the Pollution of Air, Soil and Water in the Townships of Dunn, Moulton, and Sherbrooke, Haldimand County. September, 1968. Queen's Printer, Toronto. p. 61.

** In Final Report of the Canadian Public Health Association's Task Force on Fluoride. C.P.H.A. Ottawa, 1978.

After various discussions it was decided that the study would be funded by a research grant from the Ontario Ministry of Health. Such a grant was approved for the period September 1, 1980 to March 31, 1981. Subsequently, after a number of delays in getting approvals to conduct the study through the four Boards of Education involved, the first dental examinations began in December 1980 and were completed in March 1981.



FIGURE 2: AREA SURROUNDING BRAMPTON BRICK PLANT



II. THE PRESENT DENTAL STUDY DESIGN

GENERAL RESEARCH HYPOTHESIS TO BE ASSESSED

The survey proposed to assess the extent of both non-fluoride and fluoride-induced enamel mottling in specific tooth surfaces of children attending schools located within a radius of about two miles of the Toronto and Brampton brick plants. In general, the average elementary school child would have had to live in the region at least three years (and often much more than that) prior to examination in order that the examined tooth crowns would have been developing and calcifying before eruption at the time of the industrial fluoride exposure. Because of the high mobility within and, particularly, from outside into each region, the dental examiners would be unaware of the residency of the children during the critical tooth calcification times.* Some children would have moved to the area recently and others would have lived all their lives at their present residence; since staff separate from the dental team recorded this information and did not reveal it, the dentists would, in effect, be blind as to each child's prior residence.

Subsequently, comparisons will be made of the prevalence and severity of enamel fluorosis (1) in teeth "exposed" and "unexposed" to the air-borne fluoride during the critical tooth formation periods, and (2) in children residing in the brick plant area in the critical periods but at varying distances and directions from the plant. These comparisons will permit identification and approximate quantification of the extra burden, if any, that the brick plant fluoride emissions have imposed. Children who resided during the critical tooth crown formation periods in other water fluoride areas in Ontario** but who, according to the Ministry of the Environment's estimates, had not been exposed to industrial fluoride emissions at these places, would be particularly suitable for the comparisons as "unexposed" control children. Also, identification of the influence of personal dietary or preventive use of fluoride on tooth mottling, if any, would be facilitated in the analysis by using these factors as "control" variables in cross tabulations.

* Indeed, as was learned later in the analysis, just 25% of the children examined had lived all their lives in the same residence within about two miles from the brick plants.

** The water of Toronto and Brampton is fluoridated.

TARGET STUDY GROUPS

As mentioned above, children attending elementary schools within about a one mile radius of each brick plant were to be examined. Nine schools in Toronto and three schools in Brampton fitted this description. In addition, three schools further than one mile from the Toronto brick plant were selected as it was learned that some children from two of these resided within one mile of the plant. Also, some of these children not residing within one mile, as well as the children in the third, extra school would help in the comparative analysis in terms of the assessment of distance (and to a lesser extent, direction) on any dentally identifiable environmental fluoride burden.

Although it was hoped initially that other schools in addition to the 15 initially identified could be added in both Toronto and Brampton, staff resources and available time did not permit this.

Based on the teeth they would likely present for examination (and in one instance, the highest age group available in some schools), children in senior kindergarten, grades two and six were selected for examination. Dentally these grades of children would likely display primary dentitions, both primary and permanent dentitions, and (mainly) permanent dentitions, respectively.

DENTAL FLUOROSIS SCORING

Two systems were considered for scoring dental fluorosis -- Dean's traditional classification (Dean, 1934) and Thylstrup's and Fejerskov's very recent (1978) approach. Although Dean's method, which scores the individual (according to the two worst teeth) as having very mild, mild, moderate or severe dental fluorosis (or as normal or questionable), has been used for over forty years, its sensitivity and weighting factors have recently been questioned.* Thylstrup and others (1978) have developed a ten-point scale for scoring fluorotic enamel surfaces (Table 3). The scale is based on clinical, epidemiologic and histologic considerations.

* The Dean index also poses particular difficulties and creates some ambivalence when assessing fluorosis of very low degrees since the "questionable" category includes a designation of enamel hypocalcifications that are explicitly described as not being fluoride-induced.

TABLE 3

THYLSTRUP AND FEJERSKOV'S FLUOROTIC
TOOTH SURFACE SCORING CODES

Score

- 0 Normal translucency of enamel remains after prolonged air-drying.
- 1 Narrow white lines located corresponding to the perikymata.
- 2 Smooth surfaces
More pronounced lines of opacity which follow the perikymata.
Occasionally confluence of adjacent lines.
- Occlusal surfaces
Scattered areas of opacity < 2 mm in diameter and pronounced opacity of cuspal ridges.
- 3 Smooth surfaces
Merging and irregular cloudly areas of opacity. Accentuated drawing of perikymata often visible between opacities.
- Occlusal surfaces
Confluent areas of marked opacity. Worn areas appear almost normal but usually circumscribed by a rim of opaque enamel.
- 4 Smooth surfaces
The entire surface exhibits marked opacity or appears chalky white. Parts of surface exposed to attrition appear less affected.
- Occlusal surface
Entire surface exhibits marked opacity. Attrition is often pronounced shortly after eruption.
- 5 Smooth and occlusal surfaces
Entire surface displays marked opacity with focal loss of outermost enamel (pits) < 2 mm in diameter
- 6 Smooth surfaces
Pits are regularly arranged in horizontal bands < 2 mm in vertical extension
- Occlusal surfaces
Confluent areas < 3 mm in diameter exhibit loss of enamel.
Marked attrition.
- 7 Smooth surfaces
Loss of outermost enamel in irregular areas involving < ½ of entire surface
- Occlusal surfaces
Changes in the morphology caused by merging pits and marked attrition.
- 8 Smooth and occlusal surfaces
Loss of outermost enamel involving > ½ of surface.
- 9 Smooth and occlusal surfaces
Loss of main part of enamel with change in anatomic appearance of surface. Cervical rim of almost unaffected enamel is often noted.

Scoring is applied separately to dried labial/buccal, lingual and occlusal tooth surfaces. This system has been shown to be more sensitive in both low and high dental fluorosis situations than Dean's index which essentially is a cruder, public health index measuring cosmetic levels of dental fluorosis (Thylstrup et al. 1978, 1979; Fejerskov et al., 1977). Therefore, the Thylstrup and Fejerskov enamel fluorosis index was selected for use in this study.*

Localized, non-fluoride tooth opacities that mimic the fluoride-induced ones also exist, sometimes in surprisingly high proportions, in both fluoridated and non-fluoridated water areas. Fortunately it is possible, though at times difficult, to distinguish between these two types of tooth mottling. This discrimination is desirable in this study since Thylstrup's and Fejerskov's index assesses enamel fluorosis only. Therefore, a scale of 0, 1, 2 to classify these specific non-fluoride opacities, which recently have been extensively described by Small and Murray (1978), will also be utilized in this study.

TEETH SELECTED FOR SCORING

Normally all surfaces of the available permanent and deciduous teeth present in a child are subjected to the 10-point fluorosis scoring scale described in Table 3. The deciduous teeth previously were not believed to display very much fluorosis; however, recent work dispells this notion, although the amount of fluorosis is lower than with the permanent teeth (Fejerskov, Thylstrup and Larsen, 1977; Thylstrup, 1978).

Professor Thylstrup visited the Faculty of Dentistry, University of Toronto, to give a lecture in October 1980. At that time it was learned that, based on work presented in a soon to be published paper (Wenzel and Thylstrup, 1981), the labial surfaces of the upper permanent central incisors and the buccal surfaces of the upper second permanent premolars were sufficiently representative of all surfaces and all permanent teeth when using the Thylstrup and Fejerskov index.

* As described shortly, a modification of their general index as suggested by Thylstrup was actually employed.

Since when using this index each surface to be examined must be thoroughly dried for a period of at least one minute, examination of all tooth surfaces of all teeth would be very time-consuming per child. This, in turn, would probably have required that only a sample of children, with parental agreement, could be examined in each of the 15 schools. Thus the information provided by Professor Thylstrup and his subsequent recommendation that just the representative two surfaces be examined in each child* were very welcome. The saving in time would permit a much larger group of children with probably no sampling being required and, apparently, no great loss in the validity of the data. The larger sample size would also facilitate later statistical comparisons.**

Although the conclusions and recommendations of Professor Thylstrup referred to upper permanent teeth, it was decided that when the designated tooth space for either of the two "target" permanent teeth was occupied by a primary incisor or molar, this primary tooth's labial or buccal surface would be scored for fluorosis.

Having decided to examine four upper teeth, the critical residency exposure times during which the crown surfaces of these teeth were developing, and thus potentially susceptible to any extra fluoride, had to be determined. Using a variety of reference sources and additional extra help from Professor G.N. Nikiforuk, an expert on dental calcification, the following estimates were reached.

* Good bilaterality using the index had previously been demonstrated.

** As it turned out, even larger numbers of children would have been desirable.

CROWN ENAMEL CALCIFICATION PERIODS

<u>Tooth Number*</u>	<u>Critical Exposure Period (age in months)</u>
51	0-3 (4)**
55	0-12
11	2-60
15	24-72 (84)**

* Tooth 51 is the upper right deciduous central incisor; tooth 55 is the upper right deciduous second molar; tooth 11 is the upper right permanent central incisor and tooth 15 is the upper right second premolar.

** The end point in months for these two teeth is less clear.

PARENTAL PERMISSION, QUESTIONNAIRE AND DENTAL SURVEY FORMS

Parental permission to examine each child was mandatory, as was, for analysis, detailed information on each child participant's complete previous residency history and use of dietary and dental fluorides. Therefore, a combined permission form and questionnaire was developed. These forms along with an explanatory covering letter for parents are found in Appendix 1. Because of the known ethnic features of some of the schools, this letter and these forms were translated into three other languages (Greek, Italian and Portuguese) to facilitate parental understanding. A simple dental chart for recording dental fluorosis and localized non-fluoride opacities and the essential identifying information to permit later linking of this chart with the other forms of each child was also developed. (see Appendix 2).

III. METHODS

OFFICIAL PERMISSION TO CONDUCT THE STUDY

A revised research protocol arising from the study design just described was developed and sent to the human experimentation committee set up by the Office of Research Administration, University of Toronto. Subsequent to approval by this committee the protocol was submitted to the appropriate committee of each of the five Boards of Education having jurisdiction over the 15 study schools. These were the City of Toronto Board of Education, the Borough of East York Board of Education, the Metropolitan Toronto Separate School Board, the Dufferin-Peel Roman Catholic Separate School Board and the Peel Board of Education.

Revisions in the covering letter were suggested by one or two Boards. Further information on the ethnic breakdown in some schools was provided which led to additional translations of the parental forms. The major problem identified by the review committees of some of the Boards was the difficulty in providing the parental mailing list. It was suggested that the covering letter and consent/questionnaire form be sent home with the child and be returned the same way. This was therefore incorporated into the study design. Over two months later, after many telephone calls and further correspondence, permission to conduct the study from all five Boards was achieved. Each school principal also had to approve the study. They were sent a brief version of the study protocol and after a number of phone calls and, in some cases, visits by project staff, all principals agreed to have the study teams participate in their schools.

PROCEDURES RELATIVE TO THE PARENTAL CONSENTS AND QUESTIONNAIRES

The letter, the consent form/questionnaire and the reminder letter were available in four languages (English, Greek, Italian and Portuguese). The project's clinical staff member assigned to each school decided which language to give to a particular child. (Separate covering letters to parents were also printed for Brampton and Toronto.)

The letter and the consent/questionnaire (enclosed in an envelope) were given to all children in grades senior kindergarten, 2 and 6 in the 15 schools mentioned previously.* The children were instructed to take these forms to their parents, and, once filled out, to return them to their teachers.

Pick-ups of completed forms by project staff were made every one to four days, during which children were reminded to return their forms. New forms may have been given to students who had lost or destroyed theirs.

About 10 days after the initial letter and consent/questionnaire had been handed out, a reminder letter was given to those students who had not yet returned the consent/questionnaire. These were followed up with questionnaires when requested. (Appendix 1).

It was assumed that those parents/guardians intending to return questionnaires would have done so by three weeks after the initial handout date. Later-returned questionnaires were accepted if they were returned on, or prior to, the day(s) of the dental examination in that school.

Questionnaires were checked and coded by the staff member who had distributed them. Vague or incomplete answers, omissions, or obvious inconsistencies were checked by telephone calls and the occasional home visit. Because of the complexity of the questionnaire and need for a complete prior residency profile, a great number of follow-up phone calls were necessary.

DENTAL SURVEY METHODS

The two authors (J.T.M. and A.M.H.) who conducted the dental survey are both experienced dental epidemiologists. Articles and a series of slides describing the Thylstrup and Fejerskov fluorosis index were reviewed in order to become familiar with it. Two half-day practice sessions utilizing the index on children in the Paedodontic Department of the Faculty of Dentistry, University of Toronto were arranged. These sessions included experimentation with what seemed to be the most

* Actually in one school that was more than two and three-quarters miles east of the brick plant, only children identified by the principal as living in close proximity to the brick plant were sent consent/questionnaires.

appropriate fibre-optic light intensity setting, direction and distance and, of course, agreement on the scoring scale item applicable to each tooth surface assessed. Shortly after this Professor Thystrup, who is from Denmark, visited the Faculty to give a special lecture and the examiners took advantage of this fortuitous opportunity by arranging a special review session with him.

In the field each dentist was accompanied by a recorder who was not connected in any other way with the study or school in question. The dental survey form previously mentioned (Appendix 2) was utilized. The examination procedure involved seating the child in a portable Adec examining chair to which a Rolux fibre-optic light was attached. The light was set at its smallest focal spot and middle intensity 12 inches from, and at an angle of about 70 degrees to the tooth surface. The status of the labial surface of the right* maxillary anterior tooth (11 or 51) was determined and recorded according to the ten-point scoring scale (see previous Table 3) after this surface was thoroughly dried with a cotton roll for one minute. Following this, the occurrence of non-specific opacities, not believed due to fluoride, was scored in each horizontal one-third of the labial surface according to a three-point scale: 0 = no non-specific opacity; 1 = an opacity; 2 = pitting. The buccal surface of the right* maxillary posterior tooth (15 or 55) was then similarly dried and scored and recorded.

The dental examinations were carried out in each school as soon as possible after the return, apparently, of all consent/questionnaires in that school. Many schools required a return by the dental examination team to pick-up absentees. Despite this effort, 42 children whose parents had originally consented to the examination of their child were not examined.

About 95 children per school day, on average, were examined, although this varied somewhat by examiner, and the organization within each school and class.

* If the right tooth was missing, unerupted, crowned or banded the similar left upper tooth was examined; if the left tooth also could not be examined no score was recorded for this tooth.

At the beginning of the school survey a check on intra-examiner differences was made by having each dentist independently examine the same 12 children. (Each examiner and his recorder were unaware of the other examiner's scores for these children.) There was agreement on 23 of the 24 Thylstrup and Fejerskov scores. The one disagreement arose when one examiner assigned a fluorosis score of 3 to a tooth surface that the other had designated as a non-fluoride opacity in both the incisal and middle one-thirds of the tooth surface.*

DATA PROCESSING

The dental survey forms, after they were checked by the dental staff, were appended to the appropriate returned questionnaire according to each child's unique identification number. After further checking by the study's co-ordinator (C.O.) all the coded forms were key-punched. An editing program for these punch-cards was developed and the data were "cleaned" in some cases by correcting obvious errors and in others by further clarifying phone calls to parents/guardians.

Subsequently, the data were entered into a computer file and preliminary frequencies and cross-tabulations using the SPSS computer package completed. An extremely important aspect of the analysis concerned the accurate identification of the monthly residency profile of each child for the two critical tooth formation periods (see previous table). Since four teeth (two deciduous, two permanent) were involved, four such monthly profiles had to be developed. Each profile was assessed from the computer printout and coded as to one specific residency if 75 percent or more of the critical months were identical as to residency. Out of a total of 1442 children the residency histories of eighteen children were found to be so incomplete or error-filled that these children had to be discarded from this part of the analysis. Also, a number of residencies for particular tooth surfaces were so mixed that, although they were coded, they were not really useful for analysis since the residency history was indeterminate as to previous fluoride

* Since non-specific opacities are often unilateral, this occasional difficulty in distinguishing between non-fluoride and fluoride opacities would tend to be accentuated in the present survey where only teeth on one side were examined.

exposure at the critical tooth formation period.

In addition to these mixed codes, the residency codes consisted of those who resided within the region of the brick plants at the critical tooth formation period and those who did not. The brick plant residency codes utilized a grid system to locate each child. The center of the grid was the brick plant with direction being demarcated by 16 pie-shaped sections starting with the north-south co-ordinate through the plant. Distance was denoted by 9 concentric circles centered on the brick plant with each circle having a radius one-quarter of a mile greater than its inner counterpart. These nine circles, therefore, encompassed the area up to two and one-quarter miles from each plant. A tenth circle of a radius of two and three-quarters miles completed the grid. Thus there were 160 (16 x 10) specific grid residency locations coded. Because of small sample sizes in many of these locations adjacent codes in both distance and direction had to be collapsed for analysis purposes.* For the residencies in the critical period outside the grid the only non-mixed (pure) code that occurred with suitable frequency for analysis was that of children living in Ontario communities with water fluoridation and having no environmental fluoride exposure.**

Following these residency code assignments further cross-tabulations of fluorosis and opacity scores according to the critical residency location were completed. These tabulations were compared mainly to see if within each grid distance and direction from the brick plant were associated with fluorosis (or opacities) and if grid residents and outside "control" residents differed regarding fluorosis (or opacities). These findings are presented along with others in section IV of this report.

* Indeed, as shall be seen, twelve collapsed grid codes are mainly utilized -- the 4 quarters of the circle by 3 distances in each quarter.

** This means no extra environmental exposure due to known industrial sources, not the usual background air-borne exposure.

IV FINDINGS

The response and examination experience, and residency history of those examined are presented first. This is followed by the fluorosis analysis.

CONSENT/QUESTIONNAIRE AND DENTAL EXAMINATION EXPERIENCE

Table 4 gives the distribution of the response to the invitation to participate in the study according to region, school and grade. A brief summation of these results is that, overall, (ignoring noticeable variation among schools) about seventy-six percent in East York and Toronto and ninety percent in Brampton returned their consent/questionnaire forms. Of those returned about eighty-four percent agreed to have their child examined and ninety-seven percent of these were actually examined. Overall, according to grade (Table 5), the percent of forms returned was lowest in senior kindergarten ($586/746 = 74\%$) and grade six ($535/654 = 82\%$). But of those returned, the percent answering "yes" declined as grade increased (88%, 85%, 78% for senior kindergarten, grades 2 and 6, respectively).

There were 1442 children examined. Their numerical and age distribution by community, sex and grade is given in Table 6. Just over two-thirds of the total number examined resided at the time of their examination near the Toronto brick plant. The Brampton children were younger overall due largely to the proportionately fewer grade six children examined there.

RESIDENCY MOBILITY AND DISTRIBUTION

Although the dominant location of residency during the formation of the target teeth is of prime concern in the analysis, the location of the children within each brick plant's grid and the extent of prior residential mobility are also of interest. Table 7, which indicates the number of previous addresses for each child, gives a hint of the degree of mobility in the two regions. Overall, 362 children, or one-quarter of all those examined, had lived at their present address (in

TABLE 4

DISTRIBUTION AND RESPONSE TO QUESTIONNAIRE/PERMISSION
SHEET AND DENTAL EXAMINATION EXPERIENCE BY REGION AND SCHOOL

Region & School	Total Sent	Returned No.	Returned %	Number Not Returned	'Yes' Response No.	% of "Returned"	Number 'No'	Examined No.	% of 'Yes'	Number Not Examined
EAST YORK										
Bennington (01)	34	30	88.2	04	28	93.3	02	27	96.4	01
Chester (02)	337	258	76.6	79	215	83.3	43	199	92.6	16
Rolph Rd. (03)	93	84	90.3	09	78	92.9	06	76	97.4	02
Wm. Burgess (04)	180	131	72.8	49	103	78.6	28	101	98.1	02
Holy Cross (05)	18	18	100.0	00	14	77.8	04	13	92.9	01
Sub-totals	662	521	78.7	141	438	84.1	83	416	95.0	22
TORONTO										
Whitney (11)	172	159	92.4	13	152	95.6	07	147	96.7	05
Jackman (12)	226	125	55.3	101	102	81.6	23	101	99.0	01
Frankland (13)	189	117	61.9	72	91	77.8	26	87	95.6	04
Rosedale (14)	50	49	98.0	01	42	85.7	07	41	97.6	01
O.L.P.H. (15)	45	41	91.1	04	31	75.6	10	30	96.8	01
Holy Name (16)	135	115	85.2	20	81	70.4	34	81	100.0	00
St. Anselm's (17)	122	101	82.8	21	84	83.2	17	82	97.6	02
Sub-totals	939	707	75.3	232	583	82.5	124	569	97.6	14
BRAMPTON										
Kingswood (21)	214	177	82.7	37	166	93.8	11	163	98.2	03
Glendale (22)	117	111	94.9	06	93	83.8	18	91	97.8	02
St. Anne's (23)	271	255	94.1	16	204	80.0	51	203	99.5	01
Subtotals	602	543	90.2	59	463	85.3	80	457	98.7	06
Grand Totals	2203	1771	80.4	432	1484	83.8	287	1442	97.2	42

TABLE 5
DISTRIBUTION AND RESPONSE TO QUESTIONNAIRE/PERMISSION SHEET AND
DENTAL EXAMINATION EXPERIENCE BY REGION, SCHOOL AND GRADE

Region & School	No. Sent Forms			No. Returned			No. Not Returned			No. 'Yes' Response			No. 'No' Response			No. Examined			No. Not Examined		
	SrK	Gr2	Gr6	SrK	Gr2	Gr6	SrK	Gr2	Gr6	SrK	Gr2	Gr6	SrK	Gr2	Gr6	SrK	Gr2	Gr6	SrK	Gr2	Gr6
EAST YORK																					
Bennington (01)	08	10	16	07	09	14	01	01	02	07	08	13	00	01	01	07	08	12	0	0	1
Chester (02)	137	113	87	98	96	64	39	17	23	87	76	52	11	20	12	81	72	46	6	4	6
Rolph Rd. (03)	25	38	30	24	38	22	01	00	08	24	35	19	00	03	03	24	35	17	0	0	2
Wm. Burgess (04)	61	54	65	33	52	46	28	02	19	25	42	36	08	10	10	24	41	36	1	1	0
Holy Cross (05)	07	04	07	07	04	07	00	00	00	05	04	05	02	00	02	04	04	05	1	0	0
Sub-totals	238	219	205	169	199	153	69	20	52	148	165	125	21	34	28	140	160	116	8	5	9
TORONTO																					
Whitney (11)	32	75	65	29	68	62	03	07	03	27	64	61	02	04	01	27	64	56	0	0	5
Jackman (12)	112	46	68	49	35	41	63	11	27	44	28	30	05	07	11	43	28	30	1	0	0
Frankland (13)	65	68	56	36	41	40	29	27	16	31	29	31	05	12	09	28	29	30	3	0	1
Rosedale (14)	12	16	22	11	16	22	01	00	00	10	14	18	01	02	04	10	14	17	0	0	1
O.L.P.H. (15)	14	10	21	13	10	18	01	00	03	12	09	10	01	01	08	11	09	10	1	0	0
Holy Name (16)	38	46	51	32	43	40	06	03	11	25	33	23	07	10	17	25	33	23	0	0	0
St. Anselm's (17)	41	48	33	31	42	28	10	06	05	27	34	23	04	08	05	25	34	23	2	0	0
Sub-totals	314	309	316	201	255	251	113	54	65	176	211	196	25	44	55	169	211	189	7	0	7
BRAMPTON																					
Kingswood (21)	107	107	-	92	85	-	15	22	-	87	79	-	05	06	-	87	76	-	0	3	-
Glendale (22)	46	30	41	41	29	41	05	01	00	36	27	30	05	02	11	35	26	30	1	1	0
St. Anne's (23)	91	88	92	83	82	90	08	06	02	70	68	66	13	14	24	69	68	66	1	0	0
Sub-totals	244	225	133	216	196	131	28	29	02	193	174	96	23	22	35	191	170	96	2	4	0
Grand Totals All Schools	796	753	654	586	650	535	210	103	119	517	550	417	69	100	118	500	541	401	17	9	16

TABLE 6

NUMBERS AND MEAN AGE OF CHILDREN EXAMINED
BY COMMUNITY, SEX AND GRADE

<u>Child Group</u>	<u>N</u>	<u>Mean Age (S.D.)</u> <u>(months)</u>	
All	1442	83.7	(29.7)
All - Toronto/E. York	985	86.1	(30.1)
Males - Toronto/E. York	466*	85.3	(30.4)
Females - Toronto/E. York	518*	86.7	(29.9)
Sr. K. - Toronto/E. York	309	53.7	(3.7)
Gr. 2 - Toronto/E. York	371	78.9	(5.1)
Gr. 6 - Toronto/E. York	305	127.6	(6.0)
All - Brampton	457	78.5	(27.8)
Males - Brampton	226	78.6	(28.6)
Females - Brampton	231	78.4	(27.1)
Sr. K. - Brampton	191	53.8	(3.6)
Gr. 2 - Brampton	170	79.0	(5.9)
Gr. 6 - Brampton	96	126.9	(5.0)

*Sex miscoded for 1 child in Toronto/East York.

TABLE 7

NUMBER OF PREVIOUS ADDRESSES BEYOND PRESENT ADDRESS

<u>No. of Previous</u> <u>Addresses</u>	<u>Toronto/E. York</u>		<u>Brampton</u>		<u>All</u>	
	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>	<u>N</u>	<u>%</u>
None	313	(31.8)	49	(10.7)	362	(25.1)
1	276	(28.0)	166	(36.3)	442	(30.7)
2	191	(19.4)	109	(23.9)	300	(20.8)
3	114	(11.6)	77	(16.8)	191	(13.2)
4	50	(5.1)	43	(9.4)	93	(6.4)
5	17	(1.7)	6	(1.3)	23	(1.6)
6	12	(1.2)	4	(0.9)	16	(1.1)
7+	12	(1.3)	3	(0.6)	15	(1.1)
	985	(100.0)	457	(100.0)	1442	(100.0)

the brick plant grid) all their lives* The more recent development of the Brampton community near the brick plant is suggested by the observation that just 11 percent of Brampton (versus 32 percent of East York/Toronto children) had had no previous residence besides their present grid residence.

The distributions of the distance and of the direction of each child's residence at the time of his examination are found in Table 8 . Regarding distance, about one-quarter of the Brampton children lived within a radius of one-half of a mile from the brick plant whereas just under 6% in Toronto lived that close. Nearly 90% of Brampton and just over 54% of East York/Toronto children lived within one mile of the brick plants in their respective communities. Regarding the direction from the brick plants of their residencies at the time of examination, nearly all (97%) of the Brampton children lived in the eastern half of the grid. In Toronto the directional distribution was fairly even in three of the four quarter circles (although most lived in the N.E. quadrant). However, the southwest quarter circle contained only 7% of those examined; this is consistent with the fact that much of this quarter near the brick plant contains both parkland and older, expensive low density housing. Similarly the other differences in the numbers examined by direction and distance noted above seem generally consistent with the housing development or its lack (highways, parkland, open space) in the regions surrounding these two plants. Figures 3 and 4 depict diagrammatically the location of those examined when both distance and direction together are considered. The very low and often missing counts of children in specific sub-sections of the grid are very evident. Since due to residential mobility the number of children who lived within the grid at the critical tooth formation periods is even smaller, the need for combination of the numbers of children in adjacent grid sub-sections for analysis purposes is also evident.

ENVIRONMENTAL FLUORIDE VERSUS DENTAL FLUOROSIS AND OPACITIES

As stated in part II of this report this analysis involves comparisons of the prevalence and severity of enamel fluorosis using the Thylstrup and Fejerskov index in specific surfaces of (1) teeth exposed

* Although not evident in Table 7, a number of children, particularly in East York/Toronto, had moved within the grid.

TABLE 8

DISTANCE AND DIRECTION OF CHILDREN'S RESIDENCIES
FROM BRICK PLANT AT EXAMINATION TIME

<u>Distance (miles)</u>	<u>E. York/ Toronto</u>	<u>Brampton</u>	<u>Direction*</u>	<u>E. York/ Toronto</u>	<u>Brampton</u>
0.00-0.25	1	10	N & NE	64	34
0.25-0.50	56	106	NE & E	305	150
0.50-0.75	186	180	E & SE	243	173
0.75-1.00	288	113	SE & S	21	87
1.00-1.25	242	35	S & SW	21	10
1.25-1.50	110	6	SW & W	49	0
1.50-1.75	35	3	W & NW	142	0
1.75-2.00	42	1	NW & N	133	2
2.00-2.25	6	0	Totals	978**	456**
2.25-2.75	12	2			
Totals	978**	456**			

* Directional codes are presented as adjacent pairs.

** 7 additional children in E. York/Toronto and 1 in Brampton attended school within but live outside the brick plant grid.

FIGURE 3: RESIDENCY LOCATION OF EXAMINED CHILDREN NEAR TORONTO BRICK

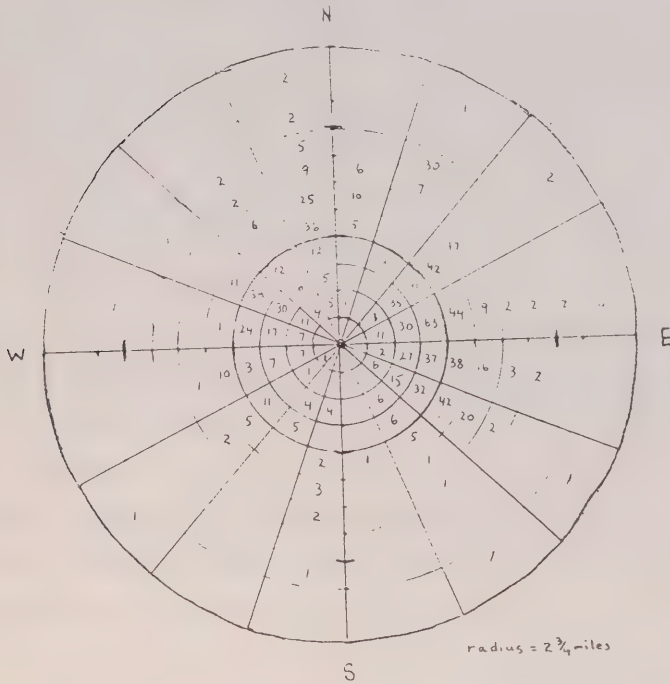
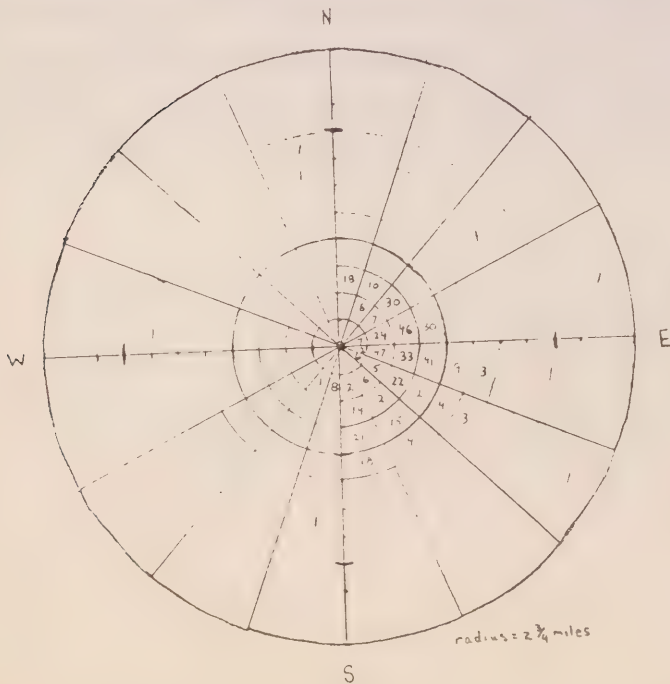


FIGURE 4: RESIDENCY LOCATION OF EXAMINED CHILDREN NEAR BRAMPTON BRICK



and unexposed to air-borne fluoride and (2) the teeth in children residing near the brick plants but at different distances and directions from them. For both situations the critical period of exposure was each tooth's formation period.* Since certain foods (fish and tea, for example) and dental products (many toothpastes, some mouthrinses and dental preparations) contain fluoride, any differences in their usage must be accounted for in the analysis. Also, since non-specific tooth opacities may mimic fluoride-induced ones and, with varying intake of fluoride, may have a prevalence inversely related to the prevalence of fluoride defects, these opacities must be considered in the analysis.

There were no statistically significant differences between the sexes in the fluorosis index scores nor, with one exception, in the non-fluoride opacity scores. Therefore, the scores are presented with the sexes combined.

The environmental fluoride analysis proposed here involves many comparisons. These are complicated because there are 3 ordinal level types of scores for 4 teeth in children who lived in 12 residential sections of the geographic grid around each brick plant in two communities and one "control" area during the development of these teeth. An additional complication is that the sample sizes are small in Brampton in all but one quarter circle (SE) surrounding the brick plant and the sample size is small in East York/Toronto in the SW quarter circle.

The data are presented in three sets of 4 tables each: one set for the fluorosis index scores; one set for the non-specific opacity scores; and one combined set of these two scores. A four-step approach

* Note that this approach disregards age (grade) differences in children having the same type of tooth present. This, in turn, appears to ignore any time-related differences in environmental fluoride output from the plants (Table 1). Any such concern is not entirely justified for two main reasons. Two of the teeth in question (51, 15), because of known age-related tooth eruption patterns, would occur only (or mainly) in senior kindergarten and grade 6 children, respectively. Teeth 11 and 55 which could occur in three age (grade) periods, each showed in cross-tabulations little difference in severity of fluorosis by grade and by community; thus the use of critical development periods of teeth seems justified.

to the comparison of scores with each set of tables will be used.

1. Comparisons related to the lime-candle fluoride readings. As suggested by Table 1 and Figures 1 and 2, in Toronto the "close" (0.0-0.75 mile) SE quadrant has higher fluoride readings than the "close" NW quadrant. And in Brampton the "close" section of the SE quadrant has higher fluoride levels than the next closest SE quadrant's section (0.75-1.00 mile).*
2. Comparisons within each quarter circle (NE, SE, SW, NW) according to distance from the brick plant.
3. Comparisons among the quarter circles of each distance and of each quarter circle's totals.
4. Comparisons between an environmentally unexposed Ontario control group and groups within the grid including the quarter circle and grid totals.

If it were found that a significant pattern existed in relation to distance or direction for one tooth, a fifth step would be to examine across all teeth for that particular pattern of dental fluorosis.

Sample size problems often precluded proper comparisons in Brampton and required the collapsing of adjacent table "cells" in Toronto. Wherever possible the significance of the comparisons in (above) steps 1, 2 and 3 was tested using chi-square which unfortunately ignores the ordinal nature of the scores for situations with degrees of freedom greater than 1.** With step 4 (except for the non-fluoride opacities) the Kolmogorov-Smirnov two-sample test (2-tailed) was used as the test of significance. Although this test is sensitive to ordinal level measurement, the limited number of intervals in the fluorosis scores is a problem.**

* Note the comments here are based on the limited number of yearly lime candle readings available. These do not always equate exactly to the development period of each tooth. Also residence of the child only is considered despite the fact that, at least for the permanent teeth, children may have attended school for part of the day in another section of the grid. Children move about and spend much time inside.

** The statistical analysis of the type of data arising in this study is not well developed, i.e. three to five ordinal levels scores usually highly positively skewed and often having missing or low "cell" counts. Furthermore, these data may be classified by four (or more) categories of direction and four (or more) categories of distance.

Fluorosis Scores

Using the four indicated comparative steps the Thylstrup and Fejerskov index scores for each of the four teeth will be analyzed first using the data found in Tables 9 to 12.

Regarding the historical lime candle readings in the Toronto brick plant's "close" SE and NW quarter circles (which indicate lower NW exposure) for the permanent central incisors (Table 9), the SE scores show equivalent or less fluorosis than the NW although this difference is not statistically significant.* Similarly, there was no statistically significant difference in the distribution of SE and NW scores for the second deciduous molar (Table 11). Small sample numbers prevented similar analysis with the remaining two teeth and in Brampton.

Comparisons of the distributions of the scores for the permanent central incisor (Table 9) according to distance within each quarter circle were also limited by sample size deficiencies in the SW in E. York/Toronto and in all but the SE of Brampton. The pattern in the quarters with sufficient numbers is very irregular. In the NE quarter (EY/Tor) teeth at the furthest distance (1.0-2.75 miles) have the worst (i.e. highest) scores, those in the middle distance the best and those in the closest region the middle scores; however these differences are not statistically significant. In the SE quarter there is an apparent gradient between severity and distance; however, it is in the opposite direction to expectation but again is not significant. Brampton's pattern for this tooth in the SE quarter is similar. In the E. York/Toronto SE quarter circle the pattern from close to far is U-shaped with 71% and 70% "near" and "far", respectively, showing no fluorosis and 63% in the middle, 0.75 to 1.0 mile range showing none; these differences are not significant.

With the deciduous central incisor (Table 10) the first notable thing is that the general level of fluorosis scores is lower (about 90%, no defect) than with the permanent incisor just discussed (64% to 70%, no defect). With this tooth the distribution pattern of the scores relative to distance within each quarter circle is also irregular. Too

*The 5% level of significance is used through this report, even though this is not mentioned later.

TABLE 9

UPPER PERMANENT CENTRAL INCISOR FLUOROSIS SCORES BY DIRECTION AND DISTANCE FROM BRICK PLANT

Direction (quarter)	Distance (miles)	E. York/Toronto Scores				Row Totals	Brampton Scores				Row Totals
		0	1	2	3		0	1	2	3	
NE	0.0-0.75	14 (63.6)	1 (4.5)	6 (27.3)	1 (4.5)	22	0	0	1	0	1
	.75-1.00	15 (75.0)	1 (5.0)	3 (15.0)	1 (5.0)	20	0	0	0	0	0
	1.0-2.75	19 (54.3)	5 (14.3)	7 (20.0)	4 (11.4)	35	3	0	0	0	3
	NE sub-totals	48 (62.3)	7 (9.1)	16 (20.8)	6 (7.8)	77	3	0	1	0	4
SE	0.0-0.75	14 (70.0)	3 (15.0)	1 (5.0)	2 (10.0)	20	3	1	0	0	4
	.75-1.00	18 (62.1)	4 (13.8)	3 (10.3)	4 (13.8)	29	7 (77.8)	0	1	1*	9
	1.0-2.75	39 (60.9)	16 (25.0)	7 (10.9)	2 (3.1)	64	11 (64.7)	3	3	0	17
	SE sub-totals	71 (62.8)	23 (20.4)	11 (9.7)	8 (7.1)	113	21 (70.0)	4 (13.3)	4 (13.3)	1 (3.33)	30
SW	0.0-0.75	2	0	2	1	5	1	0	0	0	1
	.75-1.00	5	1	0	0	6	0	0	0	0	0
	1.0-2.75	9	0	2	3	14	0	0	0	0	0
	SW sub-totals	16 (64.0)	1 (4.0)	4 (16.0)	4 (16.0)	25	1	0	0	0	1
NW	0.0-0.75	15 (71.4)	2 (9.5)	3 (14.3)	1 (4.8)	21	0	0	0	0	0
	.75-1.00	17 (63.0)	3 (11.1)	5 (18.5)	2 (7.4)	27	0	0	0	0	0
	1.0-2.75	23 (69.7)	3 (9.1)	5 (15.2)	2 (6.1)	33	0	0	0	0	0
	NW sub-totals	55 (67.9)	8 (9.9)	13 (16.0)	5 (6.2)	81	0	0	0	0	0
GRID TOTALS		190 (64.2)	39 (13.2)	44 (14.9)	23 (7.8)	296	25 (71.4)	4 (11.4)	5 (14.2)	1* (2.9)	35
"CONTROLS"		32 (65.3)	6 (12.2)	8 (16.3)	3* (6.1)	49	28 (54.9)	6 (11.8)	13 (25.5)	4 (7.8)	51

* One of these scores actually is '4'.

TABLE 10

UPPER DECIDUOUS CENTRAL INCISOR FLUOROSIS SCORES BY DIRECTION AND DISTANCE FROM BRICK PLANT

Direction (quarter)	Distance (miles)	E. York/Toronto Scores				Row Totals	Brampton Scores				Row Totals
		<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>		<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	
NE	0.0-0.75	12 (92.3)	0	1 (6.7)	0	13	3	1	0	1	5
	.75-1.00	26 (96.3)	1 (3.7)	0	0	27	4	0	0	0	4
	1.0-2.75	37 (86.0)	3 (7.0)	2 (4.7)	1 (2.3)	43	3	1	0	0	4
	NE sub-totals	<u>75</u> (90.4)	<u>4</u> (4.8)	<u>3</u> (3.6)	<u>1</u> (1.2)	<u>83</u>	<u>10</u> (76.9)	<u>2</u> (15.4)	<u>0</u>	<u>1</u> (7.7)	<u>13</u>
SE	0.0-0.75	17 (85.0)	2 (10.0)	1 (5.0)	0	20	11	1	0	0	12
	.75-1.00	13 (92.9)	0	1 (7.1)	0	14	8 (88.9)	1	0	0	9
	1.0-2.75	40 (95.2)	0	1 (2.4)	1 (2.4)	42	15 (93.8)	0	1	0	16
	SE sub-totals	<u>70</u> (92.1)	<u>2</u> (2.6)	<u>3</u> (3.9)	<u>1</u> (1.3)	<u>76</u>	<u>34</u> (91.9)	<u>2</u> (5.4)	<u>1</u> (2.7)	<u>0</u>	<u>37</u>
SW	0.0-0.75	1	0	0	0	1	0	0	0	0	0
	.75-1.00	6	0	0	0	6	0	0	0	0	0
	1.0-2.75	15	0	2	0	17	3	0	0	0	3
	SW sub-totals	<u>22</u> (91.7)	<u>0</u>	<u>2</u> (8.3)	<u>0</u>	<u>24</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>3</u>
NW	0.0-0.75	7	0	2	1	10	0	0	0	0	0
	.75-1.00	14 (93.3)	0	0	1 (6.7)	15	0	0	0	0	0
	1.0-2.75	28 (93.3)	0	1 (3.3)	1 (3.3)	30	0	0	0	0	0
	NW sub-totals	<u>49</u> (89.1)	<u>0</u>	<u>3</u> (5.5)	<u>3</u> (5.5)	<u>55</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
GRID TOTALS		216 (90.8)	6 (2.5)	11 (4.6)	5 (2.1)	238	47 (88.7)	4 (7.5)	1 (1.9)	1 (1.9)	53
"CONTROLS"		65 (92.9)	0	4 (5.7)	1 (1.4)	70	107 (87.0)	4 (3.3)	10 (8.1)	2* (1.6)	123

* One of these scores is actually a '4'.

TABLE 11

UPPER DECIDUOUS SECOND MOLAR FLUOROSIS SCORES BY DIRECTION AND DISTANCE FROM BRICK PLANT

Direction (quarter)	Distance (miles)	E. York/Toronto Scores				Row Totals	Brampton Scores				Row Totals
		0	1	2	3		0	1	2	3	
NE	0.0-0.75	28 (93.3)	2 (6.7)	0	0	30	4	0	1	0	5
	.75-1.00	42 (89.4)	3 (6.4)	2 (4.3)	0	47	5	0	0	0	5
	1.0-2.75	58 (77.3)	9 (12.0)	7 (9.3)	1 (1.3)	75	5	2	1	0	8
	NE sub-totals	<u>128</u> (84.2)	<u>14</u> (9.2)	<u>9</u> (5.9)	<u>1</u> (0.7)	<u>152</u>	<u>14</u> (77.8)	<u>2</u> (11.1)	<u>2</u> (11.1)	<u>0</u>	<u>18</u>
SE	0.0-0.75	28 (87.5)	2 (6.3)	2 (6.3)	0	32	17 (89.5)	2 (10.5)	0	0	19
	.75-1.00	30 (90.9)	3 (9.1)	0	0	33	12 (85.7)	2 (14.3)	0	0	14
	1.0-2.75	84 (88.4)	9 (9.5)	2 (2.1)	0	95	22 (68.8)	4 (12.5)	6 (18.8)	0	32
	SE sub-totals	<u>142</u> (88.8)	<u>14</u> (8.8)	<u>4</u> (2.5)	<u>0</u>	<u>160</u>	<u>51</u> (78.5)	<u>8</u> (12.3)	<u>6</u> (9.2)	<u>0</u>	<u>65</u>
SW	0.0-0.75	4	0	0	0	4	0	0	0	0	0
	.75-1.00	10	0	0	0	10	0	0	0	0	0
	1.0-2.75	25 (78.1)	4 (12.5)	3 (9.4)	0	32	4	0	0	0	4
	SW sub-totals	<u>39</u> (84.8)	<u>4</u> (8.7)	<u>3</u> (6.5)	<u>0</u>	<u>46</u>	<u>4</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>4</u>
NW	0.0-0.75	29 (90.6)	1 (3.1)	1 (3.1)	1 (3.1)	32	0	0	0	0	0
	.75-1.00	34 (77.3)	3 (6.8)	4 (9.1)	3* (6.8)	44	0	0	0	0	0
	1.0-2.75	53 (74.6)	8 (11.3)	9 (12.7)	1* (1.4)	71	1	0	0	0	1
	NW sub-totals	<u>116</u> (78.9)	<u>12</u> (8.2)	<u>14</u> (9.5)	<u>5</u> (3.4)	<u>147</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>1</u>
GRID TOTALS		425 (84.2)	44 (8.7)	30 (5.9)	6 (1.2)	505	70 (79.5)	10 (11.4)	8 (9.1)	0	88
"CONTROLS"		121 (89.6)	3 (2.2)	10 (7.4)	1 (0.7)	135	165 (84.2)	17 (8.7)	14 (7.1)	0	196

* One of these scores is actually a '5'.

TABLE 12

UPPER PERMANENT SECOND PREMOLAR FLUOROSIS SCORES BY DIRECTION AND BY DISTANCE FROM BRICK PLANT

Direction (quarter)	E. York/Toronto Fluorosis Score				Row Totals	Brampton Fluorosis Scores			
	0	1	2	3		0	1	2	3
NE	17 (73.9)	2 (8.7)	3 (13.0)	1 (4.3)	23				
SE	20 (50.0)	5 (12.8)	10 (25.0)	2 (5.0)	40				
SW	3	1	2	0	6				
NW	11 (68.8)	3 (18.8)	0	2 (12.5)	16				
Grid Totals	51 (60.0)	11 (12.9)	15 (17.6)	5 (5.9)	85	10	1	0	0
"Controls"	10	2	1	0	13	9	0	2	3***
Distance (miles)									14
0.0-0.75	12 (57.1)	4 (19.0)	4 (19.0)	1 (8.3)	21				
.75-1.00	16 (72.7)	1 (4.5)	2 (9.1)	1 (4.5)	22				
1.0-2.75	23 (54.8)	6 (14.3)	9 (21.4)	3 (7.1)	42				
Grid Totals	51 (60.0)	11 (12.9)	15 (17.6)	5 (5.9)	85	10	1	0	0
									11**

* One of these scores actually is an '8'.

** Since there is a total of only 11 teeth, no breakdowns are given.

*** One of these scores is actually a '4' and one is a '5'.

few of these teeth show non-zero fluorosis index scores to permit tests of significance in each quarter according to distance but this finding in itself reveals that there are no important systematic relationships to report.

With the second deciduous molars (Table 11), although overall 80% to 84%* display no fluorosis, scores are lower near the plant and get progressively higher as the distance from it increases in the NE and NW quarters of the E. York/Toronto grid and the SE quarter of Brampton. These findings, which are opposite to expectation since there is apparently a marked dropped off in fluoride with distance, are however not significant in E. York/Toronto. (small cell sample size in Brampton precluded a test of significance). The scores in the SE quarter of E. York/Toronto show a non-significant, rather flat, reverse U type of distribution pattern.

Sample size for the second permanent premolar scores in both communities prevented comparisons of differences in score distribution according to distance from the brick plant in each quarter circle (Table 12).

Next the dental fluorosis index data in these same four tables (9 to 12) are examined by comparing the scores of each of the three distance categories and of each of the quarter's sub-totals among the four directional quarter circles. For the first permanent central incisor in East York/Toronto (Table 9) there were no significant differences in the distribution of scores for each specific distance among the four quarter circles. Also there was no significant difference among the sub-total scores of each quarter circle. This analysis was not possible in Brampton due to sample size deficiencies. Too few defects were found in the deciduous central incisors (Table 10) to permit tests of significance at each distance among the four quarter circles; however, this emphasizes the lack of a meaningful pattern with these teeth** In the E. York/Toronto quarter sub-totals there were sufficient numbers for significance testing but once again the differences in score distributions were non-significant.

* This excludes the "controls".

** Meaningful, that is from the perspective of the occurrence of dental fluorosis.

With the second deciduous molar (Table 11) there were too few defects close to the plant in Toronto for analysis; however, at both the middle and further distances there were no significant differences among quarter circles. In both E. York/Toronto and Brampton (NE vs. SE) there were no significant differences among quarter circle sub-total fluorosis scores. Similarly, as shown in Table 12 there was no significant difference for the permanent second premolar quarter circle sub-total scores. (excluding SW where the sample was small).

Finally in this assessment of the fluorosis index scores the Kolmogorov-Smirnov two-sample test was utilized (wherever sample size permitted) to compare the Ontario control scores with the directional quarter circle sub-total and overall grid scores for the permanent and deciduous central incisors (Tables 9 and 10) and deciduous second molar (Table 11). No significant differences were found.

Non-specific Opacity Scores

Although these opacities are judged to be of idiopathic (but non-fluoride) origin, the opportunity to assess whether their occurrence bears any real relationship to geographic location should not be passed by. This section uses the same four-step process to make this assessment. The appropriate tables are numbers 13 to 16.

Regarding the known lime candle reading differences between the "close" SE and NW quarters of the E. York/Toronto grid whereby the SE fluoride level was higher, Table 13 shows that for the permanent central incisor the percent with opacities in the "close" SE quarter is lower than the NW; this difference is however not significant. For the second deciduous molar, the only other tooth with sufficient numbers to test, the prevalence of opacities in the "close" SE quarter circle is also lower and this difference (only with uncorrected chi-square) is of borderline statistical significance (Table 15). Thus the level of opacity appears to be lower ($5/32 = 15.6\%$) in the area tending to have relatively more environmental fluoride than in the other area ($12/32 = 37.5\%$).

The comparisons within each quarter circle of variations in the prevalence of opacities at different distances from the brick plant provided no remarkable findings. Whenever the data presented in Tables 13 to 16 had numbers large enough to permit statistical analysis no

TABLE 13

UPPER PERMANENT CENTRAL INCISOR NON-SPECIFIC OPACITY SCORES BY DIRECTION AND DISTANCE FROM BRICK PLANT

Direction (quarter)	Distance (miles)	E. York/Toronto Scores			Row Totals	Brampton Scores			Row Totals
		<u>0</u>	<u>1</u>	<u>2</u>		<u>0</u>	<u>1</u>	<u>2</u>	
NE	0.0-0.75	18 (82.8)	2 (9.1)	2 (9.1)	22	1	0	0	1
	.75-1.00	16 (80.0)	4 (20.0)	0 (0.0)	20	0	0	0	0
	1.0-2.75	26 (74.3)	8 (22.9)	1 (2.9)	35	3	0	0	3
	NE sub-totals	<u>60</u> (77.9)	<u>14</u> (18.2)	<u>3</u> (3.9)	<u>77</u>	<u>4</u>	<u>0</u>	<u>0</u>	<u>4</u>
SE	0.0-0.75	15 (75.0)	5 (25.0)	0	20	3	1	0	4
	.75-1.00	22 (75.9)	6 (20.7)	1 (3.4)	29	6	3	0	9
	1.0-2.75	54 (84.4)	10 (15.6)	0	64	17	0	0	17
	SE sub-totals	<u>91</u> (80.5)	<u>21</u> (18.6)	<u>1</u> (0.9)	<u>113</u>	<u>26</u> (97.5)	<u>4</u> (2.5)	<u>0</u>	<u>30</u>
SW	0.0-0.75	4	1	0	5	1	0	0	1
	.75-1.00	5	1	0	6	0	0	0	0
	1.0-2.75	10	3	1	14	0	0	0	0
	SW sub-totals	<u>19</u> (76.0)	<u>5</u> (20.0)	<u>1</u> (4.0)	<u>25</u>	<u>1</u>	<u>0</u>	<u>0</u>	<u>1</u>
NW	0.0-0.75	13 (61.9)	8 (38.1)	0	21	0	0	0	0
	.75-1.00	21 (77.8)	4 (14.8)	2 (7.4)	27	0	0	0	0
	1.0-2.75	27 (81.8)	6 (18.2)	0	33	0	0	0	0
	NW sub-totals	<u>61</u> (75.3)	<u>18</u> (22.2)	<u>2</u> (2.5)	<u>81</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
GRID TOTALS		231 (78.0)	58 (19.6)	7 (2.4)	296	31 (88.6)	4 (11.4)	0	35
"CONTROLS"		43 (87.8)	5 (10.2)	1 (2.0)	49	39 (76.5)	11 (21.6)	1 (2.0)	51

TABLE 14

UPPER DECIDUOUS CENTRAL INCISOR NON-SPECIFIC OPACITY SCORES BY DIRECTION AND DISTANCE FROM BRICK PLANT

Direction (quarter)	Distance (miles)	E. York/Toronto Scores			Row Totals	Brampton Scores			Row Totals
		<u>0</u>	<u>1</u>	<u>2</u>		<u>0</u>	<u>1</u>	<u>2</u>	
NE	0.0-0.75	11	2	0	13	5	0	0	5
	.75-1.00	22 (81.5)	5 (18.5)	0	27	3	1	0	4
	1.0-2.75	40 (93.0)	2 (4.7)	1 (2.3)	43	4	0	0	4
	NE sub-totals	<u>73</u> (88.0)	<u>9</u> (10.8)	<u>1</u> (1.2)	<u>83</u>	<u>12</u>	<u>1</u>	<u>0</u>	<u>13</u>
SE	0.0-0.75	19 (95.0)	1 (5.0)	0	20	11	0	1	12
	.75-1.00	11 (78.6)	3 (21.4)	0	14	8	1	0	9
	1.0-2.75	37 (90.2)	3 (7.3)	1 (2.4)	41	13 (81.3)	2 (12.5)	1 (6.3)	16
	SE sub-totals	<u>67</u> (89.3)	<u>7</u> (9.3)	<u>1</u> (1.3)	<u>75</u>	<u>32</u> (86.5)	<u>3</u> (8.1)	<u>2</u> (5.4)	<u>37</u>
SW	0.0-0.75	1	0	0	1	0	0	0	0
	.75-1.00	5	1	0	6	0	0	0	0
	1.0-2.75	11	6	0	17	3	0	0	3
	SW sub-totals	<u>17</u> (70.8)	<u>7</u> (29.2)	<u>0</u>	<u>24</u>	<u>3</u>	<u>0</u>	<u>0</u>	<u>3</u>
NW	0.0-0.75	7	2	1	10	0	0	0	0
	.75-1.00	13	1	1	15	0	0	0	0
	1.0-2.75	24 (80.0)	5 (16.7)	1 (3.3)	30	0	0	0	0
	NW sub-totals	<u>44</u> (80.0)	<u>8</u> (14.5)	<u>3</u> (5.5)	<u>55</u>	<u>0</u>	<u>0</u>	<u>0</u>	<u>0</u>
GRID TOTALS		201 (84.8)	31 (13.1)	5 (2.1)	237	47 (88.7)	4 (7.5)	2 (3.8)	53
"CONTROLS"		63 (90.0)	6 (8.6)	1 (1.4)	70	115 (93.5)	8 (6.5)	0	123

TABLE 15

UPPER DECIDUOUS SECOND MOLAR NON-SPECIFIC OPACITY SCORES BY DIRECTION AND DISTANCE FROM BRICK PLANT

Direction (quarter)	Distance (miles)	E. York/Toronto Scores			Row Totals	Brampton Scores			Row Totals
		<u>0</u>	<u>1</u>	<u>2</u>		<u>0</u>	<u>1</u>	<u>2</u>	
NE	0.0-0.75	25 (83.3)	5 (16.7)	0	30	5	0	0	5
	.75-1.00	41 (87.2)	6 (12.8)	0	47	4	1	0	5
	1.0-2.75	69 (92.0)	6 (8.0)	0	75	7	0	1	8
	NE sub-totals	135 (88.8)	17 (11.2)	0	152	16 (88.9)	1 (5.6)	1 (5.6)	18
SE	0.0-0.75	27 (84.4)	5 (15.6)	0	32	16 (84.2)	3 (15.8)	0	19
	.75-1.00	29 (87.9)	4 (12.1)	0	33	11	3	0	14
	1.0-2.75	77 (81.1)	17 (17.9)	1 (1.1)	95	28 (87.5)	4 (12.5)	0	32
	SE sub-totals	133 (83.1)	26 (16.8)	1 (0.6)	160	55 (84.6)	10 (15.4)	0	65
SW	0.0-0.75	4	0	0	4	0	0	0	0
	.75-1.00	10	0	0	10	0	0	0	0
	1.0-2.75	26 (81.3)	6 (18.7)	0	32	3	1	0	4
	SW sub-totals	40 (87.0)	6 (13.0)	0	46	3	1	0	4
NW	0.0-0.75	20 (62.5)	12 (37.5)	0	32	0	0	0	0
	.75-1.00	35 (79.5)	8 (18.2)	1 (2.3)	44	0	0	0	0
	1.0-2.75	58 (81.7)	13 (18.3)	0	71	1	0	0	1
	NW sub-totals	113 (76.9)	33 (22.4)	1 (0.7)	147	1	0	0	1
GRID TOTALS		421 (83.4)	82 (16.2)	2 (0.4)	505	75 (85.2)	12 (13.6)	1 (1.1)	88
"CONTROLS"		117 (86.7)	16 (11.9)	2 (1.5)	135	173 (88.3)	21 (10.7)	2 (1.0)	196

TABLE 16

UPPER PERMANENT SECOND PREMOLAR NON-SPECIFIC OPACITY SCORES
BY DIRECTION AND DISTANCE FROM BRICK PLANT

<u>Direction</u> <u>(quarter)</u>	E. York/Toronto Scores			<u>Row</u> <u>Totals</u>	Brampton Scores			<u>Row</u> <u>Totals</u>
	<u>0</u>	<u>1</u>	<u>2</u>		<u>0</u>	<u>1</u>	<u>2</u>	
NE	22 (95.7)	1 (4.3)	0	23				
SE	36 (90.0)	4 (10.0)	0	40				
SW	4	2	0	6				
NW	10 (62.5)	5 (31.3)	1 (6.3)	16				
Grid Totals	<u>72</u> (84.7)	<u>12</u> (14.1)	<u>1</u> (1.2)	<u>85</u>	<u>10</u>	<u>1</u>	<u>0</u>	<u>11</u>
"Controls"	12	1	0	13	14	0	0	14
<u>Distance</u> <u>(miles)</u>								
0.0-0.75	17 (81.0)	4 (19.0)	0	21				
.75-1.00	18 (81.8)	3 (13.6)	1 (4.5)	22				
1.0-2.75	37 (88.1)	5 (11.9)	0	42				
Grid Totals	<u>72</u> (84.7)	<u>12</u> (14.1)	<u>1</u> (1.2)	<u>85</u>	<u>10</u>	<u>1</u>	<u>0</u>	<u>11</u>

regular pattern to the distributions of opacity scores nor significant differences were observed.

As with the fluorosis index scores comparisons at each distance and of each directional quarter circle's sub-totals among all quarters were made again using Tables 13 to 16. Whenever sample size permitted analyses, no significant differences were found. Similarly, whenever possible, statistical comparisons between the Ontario control group and the quarter circle sub-totals and grid totals for all teeth were made; no significant differences were found in Toronto or Brampton.

Combined Fluorosis and Opacity Scores

Examination of the existence of an association between geographic grid residence and the combined fluorosis and opacity scores is of interest to the present analysis for two mean reasons. Several researchers have shown that there is an inverse relationship between fluoride and non-fluoride tooth opacities such that with increases in dental fluorosis there are concomitant decreases in the levels of non-fluoride opacities normally found in teeth. Thus fluoride may mask the presence of non-fluoride opacities. Also, it is possible in the present study (and others) that some fluoride tooth markings may be diagnosed as non-fluoride and vice versa.

This section presents combined fluorosis and opacity scores* arranged by distance and direction from the Toronto brick plant in Tables 17 to 20. The smaller numbers of teeth available for analysis in Brampton and greater number of categories in the combined scores limited the scope of the analysis there to just three teeth in the SE quarter circle (Table 20).

It is interesting to note that, overall, about 60% to 65% of the permanent teeth described in previous tables had no fluorosis while about 80% to 87% had no opacities. With the combined scores it can be seen in Tables 17 and 20 that, overall, only about 47% to 50% of the teeth have neither defect. For the deciduous teeth about 84% to 91%,

*These combined scores are: no fluorosis or opacity; opacity only; fluorosis score 1 only; fluorosis 1 plus opacities; fluorosis score 2 only; fluorosis 2 plus opacities; fluorosis score 3 only or fluorosis score 3 plus opacities.

TABLE 17

UPPER PERMANENT CENTRAL INCISOR COMBINED FLUOROSIS AND OPACITY
SCORES BY DISTANCE AND DIRECTION FROM TORONTO BRICK PLANT

Direction (quarter)	Distance (miles)	Nothing	Opacity Only	Fl. 1 Only	Fl. 1+ Opacity	Fl. 2 Only	Fl. 2+ Opacity	Fl. 3 or Fl. 3+ Opacity	Row Totals
NE	0.0-0.75	10 (45.5)	4 (18.2)	1 (4.5)	0	6 (27.3)	0	1 (4.5)	22
	.75-1.00	11 (55.0)	4 (20.0)	1 (5.0)	0	3 (15.0)	0	1 (5.0)	20
	1.0-2.75	14 (40.0)	5 (14.3)	3 (8.6)	2 (5.7)	5 (14.3)	2 (5.7)	4 (11.4)	35
	NE sub-totals	35 (45.5)	13 (16.9)	5 (6.5)	2 (2.6)	14 (18.2)	2 (2.6)	6 (7.8)	77
SE	0.0-0.75	10 (50.0)	4 (20.0)	2 (10.0)	1 (5.0)	1 (5.0)	0	2 (10.0)	20
	.75-1.00	14 (48.3)	4 (13.8)	2 (6.9)	2 (6.9)	2 (6.9)	1 (3.4)	4 (13.8)	29
	1.0-2.75	34 (53.1)	5 (7.8)	13 (20.3)	3 (4.7)	5 (7.8)	2 (3.1)	2 (3.1)	64
	SE sub-totals	58 (51.3)	13 (11.5)	17 (15.0)	6 (5.3)	8 (7.1)	3 (2.7)	8 (7.1)	113
SW	0.0-0.75	1	1	0	0	2	0	1	5
	.75-1.00	4	1	1	0	0	0	0	6
	1.0-2.75	5	4	0	0	2	0	3	14
	SW sub-totals	10 (40.0)	6 (24.0)	1 (4.0)	0	4 (16.0)	0	4 (16.0)	25
NW	0.0-0.75	7 (33.3)	8 (38.1)	2 (9.5)	0	3 (14.3)	0	1 (4.8)	21
	.75-1.00	11 (40.7)	6 (22.2)	3 (11.1)	0	5 (18.5)	0	2 (7.4)	27
	1.0-2.75	18 (54.5)	5 (15.2)	3 (9.1)	0	4 (12.1)	1 (3.0)	2 (12.1)	33
	NW sub-totals	36 (44.4)	19 (23.5)	8 (9.9)	0	12 (14.8)	1 (1.2)	5 (6.2)	81
GRID TOTALS		139 (47.0)	51 (17.2)	31 (10.5)	8 (2.7)	38 (12.8)	6 (2.0)	23 (7.8)	296
"CONTROLS"		26 (53.1)	6 (12.2)	6 (12.2)	0	8 (16.3)	0	3 (6.1)	49

TABLE 18

UPPER DECIDUOUS CENTRAL INCISOR COMBINED FLUOROSIS AND OPACITY SCORES
BY DIRECTION AND DISTANCE FROM TORONTO BRICK PLANT

Direction (quarter)	Distance (miles)	Nothing	Opacity Only	Fl. 1 only	Fl. 2 only	Fl. 2+ Opacity	Fl. 3 or Fl. 3+ Opacity	Row Totals
NE	0.0-0.75	10 (76.9)	2 (15.4)	0	1 (7.7)	0	0	13
	.75-1.00	21 (77.8)	5 (18.5)	1 (3.7)	0	0	0	27
	1.0-2.75	34 (79.1)	3 (7.0)	3 (7.0)	2 (4.7)	0	1 (2.3)	43
NE sub-totals		65 (78.3)	10 (12.0)	4 (4.8)	3 (3.6)	0	1 (1.2)	83
SE	0.0-0.75	17 (85.0)	0	2 (10.0)	0	1 (5.0)	0	20
	.75-1.00	10 (71.4)	3 (21.4)	0	1 (7.1)	0	0	14
	1.0-2.75	35 (85.4)	4 (9.8)	0	1 (2.4)	0	1 (2.4)	41
SE sub-totals		62 (82.7)	7 (9.3)	2 (2.7)	2 (2.7)	1 (1.3)	1 (1.3)	75
SW	0.0-0.75	1	0	0	0	0	0	1
	.75-1.00	5	1	0	0	0	0	6
	1.0-2.75	9 (52.9)	6 (35.3)	0	2 (11.8)	0	0	17
SW sub-totals		15 (62.5)	7 (29.2)	0	2 (8.3)	0	0	24
NW	0.0-0.75	4	3	0	2	0	1	10
	.75-1.00	12 (80.0)	2 (13.3)	0	0	0	1 (6.7)	15
	1.0-2.75	22 (73.3)	6 (20.0)	0	1 (3.3)	0	1 (3.3)	30
NW sub-totals		38 (69.1)	11 (20.0)	0	3 (5.5)	0	3 (5.5)	55
GRID TOTALS		180 (75.9)	35 (14.8)	6 (2.5)	10 (4.2)	1 (0.4)	5 (2.1)	237
"CONTROLS"		60 (85.7)	5 (7.1)	0	3 (4.3)	1 (1.4)	1 (1.4)	70

TABLE 19

UPPER DECIDUOUS SECOND MOLAR COMBINED FLUOROSIS AND OPACITY
SCORES BY DIRECTION AND DISTANCE FROM TORONTO BRICK PLANT

Direction (Quarter)	Distance (miles)	Nothing	Opacity Only	Fl. 1 only	Fl. 2 only	Fl. 2+ Opacity	Fl. 3 or Fl. 3+ Opacity	Row Totals
NE	0.0-0.75	23 (76.7)	5 (16.7)	2 (6.7)	0	0	0	30
	.75-1.00	36 (76.6)	6 (12.8)	3 (6.4)	2 (4.3)	0	0	47
	1.0-2.75	53 (70.7)	5 (6.7)	9* (12.0)	7 (9.3)	0	1 (1.3)	75
	NE sub-totals	112 (73.7)	16 (10.5)	14* (9.2)	9 (5.9)	0	1 (0.7)	152
SE	0.0-0.75	24 (75.0)	4 (12.5)	2 (6.3)	1 (3.1)	1 (3.1)	0	32
	.75-1.00	27 (81.8)	3 (9.1)	3* (9.1)	0	0	0	33
	1.0-2.75	66 (69.5)	18 (18.9)	9 (9.5)	2 (2.1)	0	0	95
	SE sub-totals	117 (73.1)	25 (15.6)	14* (8.8)	3 (1.9)	1 (0.6)	0	160
SW	0.0-0.75	4	0	0	0	0	0	4
	.75-1.00	10	0	0	0	0	0	10
	1.0-2.75	19 (59.4)	6 (18.8)	4 (12.5)	3 (9.4)	0	0	32
	SW sub-totals	33 (71.7)	6 (13.0)	4 (8.7)	3 (6.5)	0	0	46
NW	0.0-0.75	17 (53.1)	12 (37.5)	1 (3.1)	1 (3.1)	0	1 (3.1)	32
	.75-1.00	25 (56.8)	9 (20.5)	3 (6.8)	4 (9.1)	0	3** (6.8)	44
	1.0-2.75	43 (60.6)	10 (14.1)	8 (11.3)	7 (9.9)	2 (2.8)	1** (1.4)	71
	NW sub-totals	85 (57.8)	31 (21.1)	12 (8.2)	12 (8.2)	2 (1.4)	5 (3.4)	147
GRID TOTALS		347 (68.7)	78 (15.4)	44 (8.7)	25 (5.0)	5 (1.0)	6 (1.2)	505
"CONTROLS"		104 (77.0)	17 (12.6)	3 (2.2)	9 (6.7)	1 (0.7)	1 (0.7)	135

* One of these scores actually has an opacity as well.

** One of these scores includes a fluorosis '5' score.

TABLE 20
SUMMARY OF COMBINED FLUOROSIS AND OPACITY SCORES FOR COMMUNITIES
AND TEETH HAVING SMALL SAMPLE SIZES

Community	Tooth	Direction (quarter)	Distance (miles)	Combined Scores		Row Totals
				Nothing	Fluorosis &/or Opacity	
East York/ Toronto	15*	NE		16 (69.6)	7 (30.4)	23
		SE		18 (45.0)	22 (55.0)	40
		SW		1	5	6
		NW		5 (31.3)	11 (68.7)	16
		Grid totals		40	45	85
		-	0.0-0.75	8 (38.1)	13 (61.9)	21
		-	.75-1.00	13 (59.1)	9 (40.9)	22
		-	1.0-2.75	19 (45.2)	23 (54.8)	42
		Grid totals		40	45	85
Brampton	11	SE	0.0-0.75	10	2	12
			.75-1.00	7	2	9
			1.0-2.75	12	4	16
		sub-totals		29 (78.4)	8 (21.6)	37
Brampton	51	SE	0.0-0.75	2	2	4
			.75-1.00	5	4	9
			1.0-2.75	11	6	17
		sub-totals		18 (60.0)	12 (40.0)	30
Brampton	55	SE	0.0-0.75	15 (78.9)	4 (21.1)	19
			.75-1.00	9 (64.3)	5 (35.7)	14
			1.0-2.75	18 (56.3)	14 (43.7)	32
		sub-totals		42 (64.6)	23 (35.4)	65

* There were only 11 cases for this tooth in Brampton so it is not tabled.

overall, had no fluorosis and just slightly less than this had no opacity. The combined scores suggest that, overall, about 80%, on average, of the deciduous incisors have no defects and about 71%, on average, of the deciduous second molars have no defects. For each grid and control group the actual breakdown of the percent of teeth with no defect of either kind, opacities only, fluorosis only and fluorosis plus opacities can be seen in Tables 17 to 20. Unfortunately in the statistical analysis of comparative steps 1 through 3, insufficient sample size in the fluorosis categories required that these be collapsed so usually the contrast is between these three categories: no defects; opacities only; and fluorosis with or without opacities.

Regarding the known lime candle reading differences in the "close" parts of the SE and NW E.York/Toronto quarter circles there were no statistically significant differences for either the permanent central incisor or the deciduous second molars, the only teeth with sufficient sample sizes.

There were no significant differences among the distributions of the combined scores within each quarter circle for the permanent central incisor (Table 17), the deciduous central incisor (Table 18) or the second deciduous molar (Table 19). Similarly, at each of the three distances there were no significant differences among the four quarter circles for these three teeth.

With the permanent and deciduous central incisors there were no significant differences among the quarter circle sub-total combined scores nor between these or the total grid scores and the Ontario control combined scores (Tables 17 and 18). However, this was not true for the deciduous second molar (Table 19); the difference is significant for the quarter circle sub-total combined scores. Since this tooth had a large sample size ($n = 505$) the chi-square test compared the distributions of scores for these four score categories (previously just three categories could be compared): (1) no defect; (2) opacities only; (3) fluorosis only; and (4) all other (higher) fluorosis scores with or without opacities. Further examination of the reason for the significance revealed that the biggest contributions to the high chi-square were made because of the lower than expected actual number of "all other fluorosis scores with or without opacities" found in the SE quarter circle and the

higher than expected number of this same category in the NW quarter circle.* (It should be noted that these findings are the opposite to what might be anticipated if environmental fluoride from the Toronto brick plant were causally implicated since the dominant wind patterns suggest that the fluorosis would then be relatively higher in the SE, not NW.)

According to the Kolmogorov-Smirnov test the NW quarter circle sub-total combined scores (which showed just under 58% of the deciduous second molars had no defects at all) were significantly different from each of the following combined score distributions: the NE quarter circle sub-totals; the SE sub-totals (borderline significance); and the Ontario control totals (which showed 77% with no defects).**

Differences among the four quarter circle sub-total scores based on a dichotomization of the combined scores (no defects vs. fluorosis and/or opacity) for the permanent second premolar were of borderline significance (Table 20). Only one of the three other (Brampton) teeth in this table's portrayal of teeth with small survey sample sizes could be analyzed statistically using chi-square and the differences for it were non-significant.

DENTAL AND DIETARY FLUORIDES AND DENTAL FLUOROSIS AND OPACITIES

All of the children used fluoridated water during the time in which the teeth reported in the previous tables were forming. As provided by their parents/guardians, estimates of the use by the children of dietary and dental fluorides three years prior to the survey were also available (see questionnaire in Appendix 1). Foods and beverages such as fish and tea are high in fluoride content. Small portions of dental products containing fluorides such as mouth-rinses and dentifrices may inadvertently be swallowed, especially by young children. These foods and swallowed dental products would add to the total burden of systemic fluoride. They could, if available

* Furthermore, Table 19 shows that 10 of the 19 of these high NW scores (fluorosis 2 and fluorosis 3 with or without opacities) arose from the furthest distance in the NW quarter circle.

** The use of the Kolmogorov-Smirnov test assumes at least ordinal level measurement; the combined scores would appear to be ordinal only if "opacities only" can be said to be lower in order than fluorosis scores. Also, the limited number of available categories and high positive skew of the data makes the test less sensitive.

during tooth development and if threshold fluoride levels were exceeded, by acting alone or in combination with other (ingested and/or inhaled) systemic fluorides contribute to dental fluorosis. The personal administration (usually on a daily basis during the period of tooth formation) of fluoride tablets/droplets to simulate the process of water fluoridation in water fluoride deficient communities is a recommended procedure. However, dosages of these preparations in excess of the currently recommended levels have been shown to result in some dental fluorosis in some children. The questionnaire results showed that some of the 1442 children surveyed* had used these dietary and dental products possibly during the time when the examined teeth were forming (but hopefully not tablets while the child was living in a fluoridated community). Therefore, the utilization of these products was incorporated into this analysis of the occurrence of dental fluorosis and other tooth opacities.

The influence of diet and dental preventives was assessed in three main ways. First, regardless of residency location during tooth formation, cross-tabulations were performed to examine differences in the distribution of the Thylstrup and Fejerskov dental fluorosis scores in each of the four teeth examined according to various dietary and dental utilization patterns. These were different levels of use of dietary products (fish, tea and bottled water which sometimes is high in fluoride) and dental prevention (fluoride dentifrices, mouth-rinses, tablets and professionally-applied topical fluorides). The second method of assessment was to set up sub-groups of children according to certain fixed conditions and then either list out and compare the data profiles of all children in each sub-group or do cross tabulations of fluorosis scores. The three separate conditions were the highest dental fluorosis and non-fluoride opacity scores, the highest dietary and dental fluoride usage, and all logical combinations of dental and dietary use and non-use. Because of the possible interaction between these dietary and/or dental factors with environmental

* It should be noted that the previous fluorosis and opacity tables of this report only include those children residing in the grid surrounding each brick plant at the time of the formation of their "target" teeth (590 children in East York/Toronto and 99 in Brampton) and control children now living in either grid. These control children (148 now in East York/Toronto and 210 now in Brampton) formerly lived during the formation of their "target" teeth in Ontario communities with water fluoridation but with no known environmental fluoride exposure.

fluoride as represented by residency location differences during tooth formation, the third type of analysis was cross-tabulations by residence of the fluorosis score distributions according to differences in dietary and in dental (fluoride tablet) products. Although these three kinds of analysis took considerable effort and required extensive computer output, the results can be summarized rather succinctly because of the lack of any remarkable findings. Also, the very early development of the deciduous teeth precludes their serious consideration except in relation to fluoride tablet usage.

The cross-tabulations of each of the various dietary and dental factors with the dental fluorosis scores of each tooth type revealed no significant relationships when all the children examined were considered. Two typical examples of such relationships involving fluorosis scores of the upper permanent central incisor and a combined dietary measure and a dental one (frequency of and amount of fluoride tablet consumption) are found in Tables 21 and 22, respectively.* The row percents (in brackets) differ little or in the case of fluoride tablets, in an irregular and partially unexpected manner. Whatever differences exist, however, are (with suitable collapsing to create sufficient sample size for analysis) not statistically significant.

Although sample size limitations often prevented statistical group comparisons, there were no apparent differences in the distributions of the fluorosis scores in each of the four teeth according to the previous use or non-use of various combinations of fluoride dentifrice, mouthrinse and tablets, professional fluoride applications and dietary fluoride (tea and fish) exposure.** Next examined were the data profiles of all relevant variables of those potentially at greater risk to fluorosis based on their relatively greater use of both mouthrinsing and dietary fluoride (n = 27) and of both fluoride tablets and dietary fluoride (n = 16). However, no particular deviations between these profiles and

* The differences in the total number of teeth in each table are related to response number differences in the dietary and dental questions.

** The comparisons involved six groups which were formed as follows, with 1 meaning "use" and 0 "non-use": (1) dentifrice, mouthrinse and professional application all = 1, fish and tea = 0; (2) as in (1) but fish and tea = high use; (3) dentifrice, professional application and fluoride tablets use = 1 and fish and tea = 0; (4) as in (3) but fish and tea = high use; (5) dentifrice, professional application, fluoride tablet and fish and tea = 0; (6) as in (5) plus mouthrinse = 0.

TABLE 21

RELATIONSHIP BETWEEN REPORTED WEEKLY USE OF
FISH AND TEA AND DENTAL FLUOROSIS SCORES

Reported Fish and Tea Use Per Week	Fluorosis Scores -- Upper Permanent Central Incisors					Totals
	0	1	2	3	4	
None	180 (63.6)	37 (13.1)	49 (17.3)	15 (5.3)	2 (0.7)	283
Some*	156 (62.2)	26 (10.4)	42 (16.7)	25 (10.0)	2 (0.8)	251
Moderate**	73 (61.3)	16 (13.4)	18 (15.1)	11 (9.2)	1 (0.8)	119
	409	79	109	51	5	653

*Weekly - tea once or twice, or fish once, or combinations of these two.

**Weekly - tea 3 to 28(!) times, or fish 2 to 8(!) times, or combinations of these two.

TABLE 22

RELATIONSHIPS BETWEEN REPORTED DURATION AND AMOUNT OF
FLUORIDE TABLET ADMINISTRATION AND DENTAL FLUOROSIS SCORES

No. of Years Taken*	Tabs. per Year	Fluorosis Scores -- Upper Permanent Central Incisors					Totals
		0	1	2	3	4	
1-2 years	0	408 (63.9)	77 (12.1)	100 (15.7)	48 (7.5)	5 (0.8)	638
	1-100	5 (55.6)	0	3 (33.3)	1 (11.1)	0	9
	150-365	8 (61.5)	1 (7.7)	3 (23.1)	1 (7.7)	0	13
3-8 years	1-100	5 (83.3)	0	1 (16.7)	0	0	6
	150-365	3 (50.0)	0	3 (50.0)	0	0	6
		429	78	110	50	5	672

*Taken prior to three years ago (see Appendix 1).

those theoretically at lower risk were apparent. Following this it was decided to key in on the profiles of all relevant variables of those who displayed either fluorosis scores alone of 4 or more or fluorosis scores of 1 or more combined with an opacity for both anterior ($n = 26$) and posterior ($n = 27$) teeth. No particular pattern was evident in the data profiles of these anterior teeth except perhaps a greater tendency for a defect to also occur in the posterior teeth of these people. Therefore a similar observation in joint occurrence was, of course, made for these "high defect" posterior teeth. In addition, two-thirds (18/27) of the children with such posterior teeth had previously used fish or tea or both* whereas in the entire group just over one-half (53.7%) had done so. In addition, one-half of this group of 18 children whose parents reported some use by them of tea or fish had had moderate use of these products which is twice the expected number based on the experience overall.** It should be remembered that the questionnaire attempted to provide very qualitative estimates of prior exposure to food or dental products containing fluoride and did not attempt to determine whether this usage occurred during the exact formation period for each tooth. As well, the deciduous teeth deserve only very limited dietary and dental consideration. Nevertheless, this finding does underscore the need to consider diet in the analysis, particularly in relation to possible differences in environmental fluoride exposure as represented by distance and direction from the brick plants.

Further cross-tabulations of geographic location and fluorosis scores, but now controlled for dietary fluoride, were assessed to see whether there is some interaction between environmental and dietary fluoride, i.e. tea and fish. (The qualifying uncertainty about the timing of the dietary use should, however, be kept in mind.) Because of the nature of the available dietary information and the very early development of the deciduous teeth, only the permanent teeth will be considered. Since these cross-tabulations required that each directional and distance combination be subdivided into three dietary fluoride categories, the sub-group (or "cell") sample sizes were sharply reduced. Consequently, only the permanent central incisors in East York/Toronto

* Fifteen used tea 1 to 7 times per week, two used both tea and fish and one used only tea.

** Moderate weekly use is described in a footnote to Table 21.

children, could be examined with any degree of accuracy. With this tooth the distributions of fluorosis scores in the cross-tabulations at each of the three dietary levels at each distance in each quarter circle were very similar in nearly every instance. This suggests that utilization of the variable describing previous dietary fluoride use provides no additional explanatory value in the assessment of the geographic location and fluorosis distribution relationships.

To consider further the dietary fluoride and environmental fluoride relationship and get around the problem of small sample sizes which prevented significance testing, the fluorosis scores for the permanent central incisor were aggregated into each of the four quarter circles and into each of the three distances (Table 23). There was no significant association between the dietary fluoride levels and the dental fluorosis scores for each of the quarter circle or distance groupings.

The possibility that some previous use of systemic fluoride tablets (or drops) in excess of recommended amounts or, indeed, any systemic tablet use in the area of the brick plants which are situated in fluoridated communities might be related to the distribution of fluorosis was investigated with further cross-tabulations. (Again, as with tea and fish, this usage does not necessarily coincide with the specific tooth formation times.) The sample numbers indicating some previous usage were very small and this prevented significance testing. This was true even for the tooth with the greatest sample size -- the second deciduous molar in East York/Toronto children. An example of one of the more notable findings is that three of seven children in the NW and two of four in the SW quarter circle of East York/Toronto who had reported some previous fluoride tablet use had fluorosis scores of 1 or 2 in their deciduous second molars whereas two of ten children in each of the other two quarter circles did. As will be realized, with such small numbers these differences could easily be chance observations.

TABLE 23

PERMANENT CENTRAL INCISOR FLUOROSIS SCORES BY DIRECTION AND BY DISTANCE FROM
THE TORONTO BRICK PLANT AND BY ESTIMATED PRIOR USE OF TEA AND/OR FISH

<u>Direction</u>	<u>Dietary Fluoride*</u>	<u>Dental Fluorosis Scores</u>								<u>Row Totals</u>
		<u>0</u>	<u>(%)</u>	<u>1</u>	<u>(%)</u>	<u>2</u>	<u>(%)</u>	<u>3</u>	<u>(%)</u>	
NE	'0'	21	(72.4)	2	(6.9)	5	(17.2)	1	(3.4)	29
	'1'	17	(58.6)	4	(13.8)	5	(17.2)	3	(10.3)	29
	'2'	6		1		1		2		10
SE	'0'	28	(63.6)	11	(25.0)	2	(4.5)	3	(6.8)	44
	'1'	21	(63.6)	5	(15.2)	5	(15.2)	2	(6.1)	33
	'2'	9	(50.0)	5	(27.8)	3	(16.7)	1	(5.6)	18
SW	'0'	7		1		2		2		12
	'1'	6		0		2		1		9
	'2'	3		0		0		1		4
NW	'0'	28	(65.1)	4	(9.3)	8	(18.6)	3	(7.0)	43
	'1'	17	(73.9)	2	(8.7)	4	(17.4)	0		23
	'2'	7		1		1		1		10

<u>Distance (miles)</u>	<u>Dietary Fluoride*</u>	<u>Dental Fluorosis Scores</u>								<u>Row Totals</u>
		<u>0</u>	<u>(%)</u>	<u>1</u>	<u>(%)</u>	<u>2</u>	<u>(%)</u>	<u>3</u>	<u>(%)</u>	
0.0-0.75	'0'	19	(79.2)	0		3	(12.5)	2	(8.3)	24
	'1'	15	(68.2)	3	(13.6)	4	(18.2)	0		22
	'2'	5		3		2		1		11
.75-1.00	'0'	29	(67.4)	6	(14.0)	6	(14.0)	2	(4.7)	43
	'1'	19	(70.4)	1	(3.7)	4	(14.8)	3	(11.1)	27
	'2'	3		1		0		1		5
1.0-2.75	'0'	36	(59.0)	12	(19.7)	8	(13.1)	5	(8.2)	61
	'1'	27	(60.0)	7	(15.6)	8	(17.8)	3	(6.7)	45
	'2'	17	(65.4)	3	(11.5)	3	(11.5)	3	(11.5)	26

*'0' = none; '1' = (weekly) tea once or twice, or fish once, or combinations of these two; '2' = (weekly) tea 3 or more times, or fish 2 or more times, or combinations of these two.

V. DISCUSSION AND CONCLUSIONS

Lime-candle fluoride readings some of which are above the stated acceptable levels of the Ontario Ministry of the Environment have been reported for the Toronto brick plant since 1972 and for the Brampton brick plant since 1975. This retrospective epidemiological study assesses whether probable prior exposure to this air-borne, environmental fluoride in children who lived within 2 miles* of these plants during the time when specific teeth were developing would have the anticipated different dental fluorosis scores according to varying environmental exposure as reflected by differences in the distance and direction of their residencies at these critical times. Also would they exhibit higher scores than other Ontario children who had used fluoridated water but apparently only background levels of environmental fluoride during the critical tooth formation periods.

Since the grade 6 children in this survey were born in about 1969 and the grade 2 children in about 1973 this analysis assumes that earlier fluoride emissions did not differ substantially from those reported in Table 1, particularly for the grade 2 and 6 children in Brampton and to a lesser extent for grade 6 in East York/Toronto also. Another point in relation to the known lime candle readings is that these were higher in 1977 to 1979 (Table 1). Children born in this period would be in senior kindergarten in 1982 to 1984 and have their deciduous incisors and molars available for examination. The permanent central incisors developing during this higher fluoride period would be available for examination in schools between about 1983 and 1985 and the permanent premolars would be available between about 1988 and 1990. This is mentioned simply because of the lack of correspondence between the elevated pattern of fluoride emissions and the development of all of the teeth studied here. In view of the negative findings of this study and other ones reported earlier (see p. 6 and 7), it is very unlikely, however, that the elevated fluoride emissions in 1977-79 will have any impact on dental fluorosis.

* Actually 56 of 1124 teeth (5%) in East York/Toronto developed in children residing from 2 to 2.75 miles from the brick plant and 23 of 187 teeth (12.3%) in Brampton developed in children residing at this distance.

Although 1442 children (985 in East York/Toronto and 457 in Brampton) were dentally examined, many fewer children than this had resided in the region of the brick plants during the formation of the four "target" teeth. Just under 60% of the East York/Toronto children (590) and 22% of the Brampton children (99) had done so during the development of the two teeth examined in each child.* These reduced numbers created some analytical problems in significance testing particularly in Brampton and in both communities for the permanent second premolar. However, the available data did permit many of the expected significance tests to be done and rather firm conclusions to be drawn.

The comparisons of the distributions of the fluorosis scores, the non-specific tooth opacities and the combination of these two for each examined tooth surface developing within a two mile radius of each brick plant showed almost without exception an irregular and non-significant pattern of distribution. Thus, to the extent that differences in exposure to air-borne fluoride can be identified by distance and direction, there was no reason to attribute the fluoride and non-fluoride tooth opacities found to the fluoride emissions from either brick plant. Indeed, although these relationships were non-significant, the distributions of fluorosis and/or opacities often seemed the opposite to what might be expected if environmental fluoride were causally implicated. For example, those generally "downwind" often had lower scores than those generally "upwind"**, and those living in or near areas with apparently lower lime-candle readings had higher scores than those with higher readings.

Comparisons of the fluoride and non-fluoride opacities of children residing near the brick plants when their teeth developed revealed no differences from those of control children who had similar exposure to water fluoridation but no known environmental exposure beyond background levels. These findings provided further evidence of the lack of an environmental influence due to air-borne fluoride near the Toronto

* 148 East York/Toronto children and 210 Brampton children served as Ontario "controls". Variations in residence history and small numbers for other groups resulted in exclusions of the rest.

** While in general one might expect a positive correlation between wind direction and fluoride distribution, the whole situation is confounded by wind speed, and seasonal variations and diurnal variations in both wind direction and the concentration of fluoride emissions. Refined data on each of these parameters are not available.

and Brampton brick plants being positively associated with dental fluorosis.

The main exception to the preceding negative findings arose with the combined fluoride and non-fluoride score in the upper deciduous second molar in East York/Toronto. With this tooth it was found that there was a statistically significant association among the total combined scores for each directional quarter circle (NE, SE, SW, NW). The significance was mainly due to the levels of dental fluorosis score 2 or greater with or without opacities being greater than expected in the NW and lower than expected in the SE quarter circle for the deciduous second molar. The explanation for this difference is not clear. The dominant wind pattern in the East York/Toronto area should bring about just the opposite findings; that is, the scores should be lower in the NW. Thus air-borne fluoride is not likely implicated.

Although the statistical comparisons in Brampton were often curtailed by small sample sizes, whenever comparisons were possible no significant differences were found.

Differences in dietary use of foods such as tea and fish or in dental products containing fluoride during tooth formation might subsequently be related to differences in fluorosis scores or might somehow interact with environmental fluoride as represented by differences in residency location to give variations in dental fluorosis. Because the deciduous teeth develop in the first year of life they ordinarily are little affected by these particular dietary and dental products.* Small sample size again made some statistical comparisons impossible. However, none of the many comparisons and other assessments completed gave any solid evidence that previous dietary or dental fluoride use was positively related to fluorosis score differences or that it interacted with possible differences in environmental fluoride according to residency location to give increased fluorosis.

In summary, this study provides no evidence that earlier possible variations in exposure to air-borne, dietary or preventive dental fluorides have resulted in identifiable differences in dental fluorosis. Whatever additional systemic fluoride some children may have experienced was apparently below the threshold levels needed to produce sufficient differences in the prevalence and extent of dental fluorosis in these children.

* Fluoride tablets provided during the first year of life, particularly with the second deciduous molars, are the major exception.

Because the Thystrup and Fejerskov fluorosis index is new some comment about the distribution of the fluorosis scores arising from its use and about the opacities found in this survey are in order. The data are presented for all those examined regardless of earlier residence since the scores for those residing in Brampton and East York/Toronto during tooth development and for those acting as controls can be seen in the tables of this report.

With the maxillary permanent teeth the fluorosis scores of the anterior central incisors and second premolars were quite similar -- about 64% of the incisors and 69% of the premolars had no fluorosis on their labial or buccal surfaces and for both teeth 92% had scores of 2 or lower. This was not the same as Wenzel and Thylstrup (1981)* found using the same index since they reported that fluorosis scores got worse from the anterior to the posterior permanent teeth. They also reported with the first upper premolars that about 95% of the buccal surface of these teeth in children using low fluoride water (0.2 ppm) had no fluorosis and that about 48% of children using water containing fluoride at the 1.0 ppm level had no fluorosis on the buccal. Just 7%, approximately, of these surfaces in children using water with high fluoride (2.4 ppm) displayed no fluorosis. Thus this Ontario study findings for the second upper premolars** (about 69% overall and 64% in the brick plant grid and control groups tabled earlier had no fluorosis) appear to demonstrate fluorosis at a level about half way between the Danish low(0.2 ppm) and middle (1.0 ppm) groups.

Fluorosis scores for deciduous teeth were not reported by Wenzel and Thylstrup but based on other work fluorosis in this dentition is lower than in the permanent. The present survey findings support this since 89% of the deciduous incisors and 85% of the deciduous molars had no fluorosis on their labial/buccal surfaces. About 98% of these incisor surfaces and 99% of these molar surfaces had fluorosis scores of 2 or lower.

* Wenzel, A. and Thylstrup, A. Dental fluorosis and localized enamel opacities in fluoride and non-fluoride Danish communities. Personal Communication with D.W. Lewis, 1981.

** The paper by Wenzel and Thylstrup did not give this information for the second premolar.

The cosmetic effect of the fluorosis scores described here should be mentioned. The Thylstrup and Fejerskov scores are determined by careful dental examination with the help of a spotlight after the tooth surface has been meticulously dried with a cotton roll for one minute. This creates a special set of circumstances not normally found in ordinary visual contact with a person and helps to explain why all non-zero fluorosis scores are not normally visible. Based on the verbal description of the scoring criteria, the experience of the clinical examiners and the cross-tabulations found in the Wenzel and Thylstrup 1981 paper between the Thylstrup and Fejerskov index and Dean's fluorosis index, scores of 2 or lower are not able to be seen in normal social contact. Scores of 3 and above may, however, be noticeable to the naked eye. Thus, in the present survey about 8% of the fluorosis markings on the labial surfaces of the permanent central incisors and 2% on the deciduous central incisors might be visible.* Although the posterior teeth cannot normally be seen, their buccal surfaces have fluorosis scores of 3 or more on 8% of the permanent second premolars and on 1% of the deciduous second molars.**

In addition to fluorosis, the occurrence of non-specific opacities was independently assessed. For both the anterior and posterior teeth the order of occurrence relative to the location of the defect on the surface was similar -- more frequent occurrence on the incisal or occlusal one-third, then the middle one-third, and lowest on the gingival one-third of the tooth surface. For the two anterior teeth the percent occurrence according to the aforementioned locational preference was: 12.1%; 4.4%; and 1.2%. And for the two posterior teeth it was: 7.5%; 5.3%; and 3.2%. In from 1% to 1.5% of the tooth surfaces examined the non-specific opacity occurred in two locations (but never all three).

* For the total of 1442 children examined who had upper central anterior teeth available for scoring (n = 1296), 5.4% had fluorosis scores of 3 or higher. This was made up of 60 of 714 permanent central incisors (55 score 3; 5 score 4) and 11 of 582 deciduous central incisors (9 score 3; 2 score 4).

** For the 1442 children with upper posterior teeth available for scoring (n = 1389); 2.1% had fluorosis scores of 3 or higher. This was made up of 16 of 196 permanent second premolars (10 score 3; 4 score 4; 1 each score 5 and 8) and 12 of 1193 deciduous second molars (8 score 3; 4 score 5).

Regarding the overall prevalence of these opacities (or, really, their lack): about 80% of the permanent central incisors; 86% of the permanent second premolars; 89% of the deciduous central incisors; and 85% of the deciduous second molars had no non-specific opacities.

The combination of the fluorosis scores and non-specific opacities represents the total defects on the labial or buccal tooth surfaces. While this combination has some intrinsic value for this reason alone, it is of particular interest to the present survey because in East York/Toronto two examiners were used. It is possible that occasionally in a certain difficult decision one examiner would score the surface as fluorosis while the other would have scored it as a non-specific opacity. It is therefore important to note that, as mentioned earlier, no environmental fluoride influence was found when the combined scores were used as the unit of analysis. The following represents the percent of all those examined who had neither a fluoride nor a non-specific opacity in the labial or buccal surface of the indicated tooth: about 49% of the permanent central incisors; 57% of the permanent second premolars; 78% of the deciduous central incisors; and 70% of the deciduous second molars.

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A P P E N D I X 1

PARENTAL LETTER AND
CONSENT/QUESTIONNAIRE*

*This represents the material sent home in East York/Toronto in the English language. The letter to parents in Brampton was nearly identical. In addition, all these forms were translated into Greek, Portuguese and Italian and used as required.

Dental Health Care Services Research Unit

Faculty of Dentistry University of Toronto

Re: Brick Plant Fluoride Emission Dental Study

Dear Parent/Guardian:

Your child attends a school within a mile or so of the Toronto brick plant located in the Don Valley. The fluoride emissions into the air from this brick plant have exceeded the stated criteria recommended by the Ministry of Environment. Although these emissions are mainly localized to the immediate area of the plant, some higher than recommended levels further from the plant have been recorded.

While there is, to our knowledge, no evidence of harm to human health caused by these airborne fluoride emissions, it is important to determine whether any damage exists. The best way of identifying previous fluoride exposure is to examine teeth as they are very sensitive to certain levels of fluoride when they calcify before eruption. Therefore, research involving dental examinations of children in senior kindergarten, grades 2 and 6 of the schools nearest to the brick plant will be undertaken to see whether any tooth surfaces have the special markings that indicate extra exposure to fluoride. Dentists will merely look at the children's dried teeth using a mirror and light. Nothing else will be done; the average exam will be over in less than one minute.

Since teeth develop at various times, it is not necessary that your child has always lived where you do now. We are anxious to examine the teeth of both short- and long-term residents who live various distances from the plant.

The findings of this important research supported by a grant from the Ontario Ministry of Health will be used to determine what further studies, if any, are needed. We hope to have as many children as possible in the survey; however, participation is completely optional.

Whether you wish to have your child participate or not, please complete the appropriate part of the attached sheets and have your child return them to his/her teacher. You will see that we require extra information if your child participates.

Thank you, if further information is needed please leave a message at 978-6226.

Yours sincerely,

D. W. Lewis

D. W. Lewis, D.D.S.

Fluoride Emission Dental Study Director
Professor and Chairman,
Department of Community Dentistry

BRICK PLANT FLUORIDE EMISSION DENTAL SURVEY

--	--	--	--	--	--

Please be sure to read the attached letter explaining the background and need for a school dental survey to assess previous fluoride exposure in this region. Then indicate below whether you wish or do not wish your child to participate in this assessment and sign where indicated. Please answer the questions completely.

Your name (please print) _____ Telephone No. _____

Your child's name _____ Grade _____

Teacher's name _____ School _____

Your relationship to child (mother, father, legal guardian) _____

Do you wish your child's teeth to be examined as part of this survey?

☐

Yes - Please sign below and be sure to complete this questionnaire.

☐

NO - Please sign below and have your child take this form back to his/her teacher.

Your signature _____ Please sign (whether you have checked yes or no)

The following detailed information is essential to go along with your child's dental examination:

1. Birthdate of the above child _____ / _____ / _____
Day Month Year

2. Birthplace _____ / _____ / _____
City, Town or Borough Province, State Country

3. Your child's RESIDENCE HISTORY - THIS IS VERY IMPORTANT - We need to know ALL places this child has lived since birth, excluding brief absences for holidays, etc. This is to help us know where he/she was while different teeth were forming!

	Mailing Address Street Address, <u>CITY, TOWN, BOROUGH</u>	postal code	Approximate Dates			
			FROM		TO	
Present address:			month	year	month	year
1st previous address:						
2nd previous address:						
3rd previous address:						
4th previous address:						

We need all other home addresses of this child since birth. If necessary, please complete other addresses and dates on the back of this sheet. Thank you. /2

Please indicate whether this child :

--	--	--	--	--

I) Prior to three years ago
ate fish once or more per week? Yes () No () Don't know ()
How many times per week? _____ times

	7
	8

II) Prior to three years ago
drank tea once or more per week? Yes () No () Don't know ()
How many times per week? _____ times

	9
--	---

III) Prior to three years ago
drank commercially bottled water
one or more times per week Yes () No () Don't know ()
how many times per week? _____ times
what brands? _____

		10
		12
		13

IV) Prior to three years ago generally
used a fluoride toothpaste? Yes () No () Don't know ()
approximate brushings per day _____ times per day

	15
	16
	17

for how many years (prior to
three years ago) has a fluoride
toothpaste been used by this child About _____ years

	18
--	----

V) Prior to three years ago
used a fluoride mouth rinse
at school or at home: Yes () No () Don't know ()
School () Home ()
About how often per year? _____ times

	20
	21
	22

VI) Prior to three years ago had
fluoride applications by a
dentist/dental hygienist? Yes () No () Don't know ()
About how often per year? _____ times

	25
	26

VII) Prior to three years ago used
fluoride drops or tablets? Yes () No () Don't know ()
About how often per year? _____ times

	27
	28

for how many years prior to three
years ago were these drops or
tablets used? About _____ years

	31
--	----

Altogether, how many children age 15
and under live with you at home? _____ children

	33
--	----

Of these, how many are age 10 and under? _____

	35
--	----

How many of your children are
participating in this study? _____ are participating

	36
--	----

THANK YOU VERY MUCH. Please indicate whether you would like to have a
short summary of the findings of this study.

Yes	No

	37
--	----

PLEASE HAVE YOUR CHILD RETURN THIS FORM TO HIS OR HER TEACHER.

	38
--	----

Checked by _____

Dental Health Care Services Research Unit

Faculty of Dentistry University of Toronto

Dear Parents:

This is a reminder about the forms for the "Brick Plant Fluoride Dental Study" which we sent home with your child about 10 days ago. We are anxious to get back your signed forms. Whether or not you wish your child to participate in the study, we would like to have your forms back. If you did not receive forms, or have lost them, please fill in the bottom of this letter, and return it. We will send you another set of forms. If you have already filled them out and returned them to us, please disregard this notice. If you wish more information please call 978-6657 and leave your name, telephone number, and the name of the school your child attends. Our representative to that school will call you back.

Thank you for your cooperation.

Yours sincerely,

Clarice Ondrack

Mrs. Clarice Ondrack
Research Co-ordinator

☐

I would like more forms

Child's name _____

Child's grade _____

Teacher _____

School _____

APPENDIX 2: DENTAL SURVEY FORM

DENTAL FLUOROSIS STUDY

1. Student's Name _____ 2. I.D.

--	--	--	--	--	--	--

3. School _____ Grade _____ (Sr. K., 2, 6)

4. Student's Sex - male = 1; female = 2
card 4

--

39

5. Anterior Tooth

	1
--	---

40 41

1,2,5,6=dentition/side
7(all boxes)=missing 1,2,5,6
8(all boxes)=surf. restored " "
9(all boxes)=surf. banded " "

(i) Thylstrup's Code

--

(0-9)

42

(ii) Non-specific Defect

gingival 1/3

43

--

(0, 1, 2)

middle 1/3

44

--

(0, 1, 2)

incisal 1/3

45

--

(0, 1, 2)

Non-specific

0 = nothing
1 = opacity
2 = pits

6. Posterior Tooth No.

	5
--	---

46 47

as above in 5 (i)

(i) Thylstrup's Code

--

(0-9)

48

(ii) Non-specific Defect

gingival 1/3

49

--

(0, 1, 2)

middle 1/3

50

--

(0, 1, 2)

occlusal 1/3

51

--

(0, 1, 2)

as above in 5 (ii)

All 'boxes' and I.D. checked

Recorder's initials

